# PROCEEDINGS

# OF

# WORKSHOP ON

# SYSTEMS ANALYSIS

# IN THE

# DAIRY INDUSTRY

April 24-25, 1973
Dulles International Airport
Herndon, Virginia

CONTENTS

## Foreword

Policymakers in the U. S. Dairy industry are confronted with several major issues ranging from the impact of pollution control regulation to the impact of alternative methods of pricing and pooling milk. These issues present policymakers with a set of conflicting objectives. Further, it becomes difficult if not impossible to establish long-range research programs designed to provide information to policymakers on the traditional scientific basis of establishing and testing hypotheses.

The emphasis of this workshop was on the development of a more generalized core research program on a coordinated basis. The intent of such an effort is to develop tools (models) and build research capital (information) which can be utilized over time to provide guidance to policymakers on a timely basis.

The Economic Research Service in cooperation with several land-grant universities has initiated such an effort. While several meetings at various locations on the same general topic had been held before, the Workshop on Systems Analysis in the Dairy Industry held at Herndon, Virginia, April 24-25, 1973 was the first meeting designed to give concrete shape to the effort. The intent of the Workshop was to (1) solidify an overall plan of work, (2) inform the various participants of the efforts that had already been initiated, (3) allow interaction between all participants, and (4) permit individual researchers not now involved directly to see how they might fit their research efforts into the systems work.

Much of the contribution of a workshop such as this comes from the discussion following formal presentations. While detailed notes were taken on these discussions, no formal summary of these discussions will be attempted.

The introductory papers by Manchester and Hallberg did much to set the workshop stage by focusing attention on the topic to be emphasized and the reasons for this emphasis. The paper by Hallberg was distributed to each participant prior to the workshop so that each would have time to react to its contents ahead of time and bring these reactions to the workshop.

One of the distinctive features of the workshop was the apparent consensus over the need and desirability of systems analysis work in the dairy industry. As pointed out by Manchester, this work will help in coordinating an overall research program as well as assisting in uniting numerous individual research efforts in a common objective.

Hallberg outlined a strategy for attaining a basic supply-demand model for the dairy industry which was intended to serve as a launching point for the workshop. In addition, he suggested several areas for additional work designed to either improve what is now included in the model or to add detail to the basic model now conceived.

The remaining papers included in the proceedings gave additional detail needed for the modeling effort. Christ led a discussion on the institutional constraints operative in the dairy industry and how these constraints might be realistically captured. His paper dealt primarily with Government constraints, but in the ensuing discussion, many other

topics in this area were pursued. The paper by Sleight (distributed but not formally presented) described the rules by which support prices have been determined in the past.

One of the requirements of any serious modeling effort in the dairy industry is that it incorporate a meaningful method of accounting for all of the milk (fat and solids-not-fat) produced. The complications here are: (1) all dairy products contain different proportions of butterfat and solids-not-fat and (2) some dairy products are used as raw materials for the manufacture of other dairy products. Fallert discussed the problem in detail and suggested a method of dealing with it.

A final area of concern to the workshop participants was that of supply response and production characteristics. Two specific topics in this area were addressed: (1) estimating aggregate milk production and (2) estimating returns to dairy farming by region and size of dairy herd. Most past work in the area of supply analysis has concentrated on attempts to estimate aggregate milk production regardless of the biological considerations involved. A general overview of this work using time series and panel data was presented by Partenheimer. Hallberg discussed an estimable model based on biological or life-cycle considerations in dairy production.

The paper by Cummins was also directed to supply response--returns to dairy farming. Cummins dealt with methods of projecting the size distribution of dairy farms. While not discussed formally, it was suggested that once such a technique is developed, one can apply a farm firm

simulator such as has been devised by George E. Frick or R. F. Hutton and H. R. Hinman* to estimate farm incomes for "typical" farms in each size category and region.

R. F. Fallert
July 2, 1973

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*Hutton, R. F.; and Hinman, H. R. A General Agricultural Firm Simulator. Penn. State Univ., Dept. of Agr. Econ. and Rural Soc., Agr. Econ. and Rural Soc. 72, May 1968.

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# SYSTEMS RESEARCH IN THE DAIRY INDUSTRY

by

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The first question which we need to settle is what do we mean by subsector or systems research. Quite simply, subsector research deals with an entire subsector of the economy. For most purposes, a subsector can be regarded as that part of the economy which deals with the production and marketing of a single agricultural product or a group of related products such as pork, beef, or dairy products. It includes the usual meaning of an industry and some logical extensions thereof. For example, the hog-pork subsector includes all of the economic activities from breeding the sow through feeding, farm marketing, slaughter, processing, transportation, and wholesale and retail distribution.

In ERS, we have often used the terms systems research and subsector research as synonymous. Therefore, I will regard them as equivalent in meaning in this paper.

The term subsector research came into current use with Jim Shaffer's 1968 paper and was elaborated and somewhat modified later. 1/

1/ Shaffer, James Duncan, A Working Paper Concerning Publicly Supported Economic Research in Agricultural Marketing, Econ. Res. Serv., U.S. Dept. Agr., 1968; Shaffer, James Duncan, Changing Orientations of Marketing Research, American Journal of Agricultural Economics 50:5:1437-1449, Dec. 1969; and Shaffer, James Duncan, On the Concept of Subsector Studies. Paper from Technical Seminar on Subsector Modeling of Food and Agricultural Industries, Univ. of Fla., March 30, 1970.

In 1967, the ERS Administrator's office employed Jim Shaffer of Michigan State University as a consultant to review the state of marketing research and to make some recommendations. His report, A Working Paper Concerning Publicly Supported Economic Research and Agricultural Marketing, was published by ERS in 1968. A summary of the report and some of his more fully-developed thinking on the matter was published in the Journal of Farm Economics, December 1968, under the title, Changing Orientations of Marketing Research. Among the suggestions which Shaffer made was that the agricultural economics profession should conduct a number of subsector research efforts which would encompass the entire production and marketing system for major commodities.

A seminar was held in Lincoln, Nebraska, in May 1968 which brought together a number of people in ERS and the State colleges. (See Proceedings of Seminar Toward Better Economic Research in the Food and Fiber Industry, ERS, 1968.) Considerable interest and discussion was generated on the idea of subsector research as a result of Shaffer's paper and the seminar. The Administrator's office employed George Brandow of Pennsylvania State University under a cooperative agreement to outline a proposal for subsector research in one industry. In large part, because of Brandow's interest, the hog-pork industry was selected.

Brandow outlined A Research Framework for Economic Analysis of the Hog-Pork Subsector (February 1969). His proposal was for a fairly narrowly defined and tightly structured study of the costs involved in the hog-pork subsector from farrowing to slaughter. It involved a comparison of these costs under the free market and various forms of integration.

Shortly thereafter, a meeting was called of representatives from ERS and department heads from approximately 10 hog-producing States. This group expressed considerable interest in participating in a pioneering effort to carry out subsector research in the hog-pork industry. However, there was a general feeling in the group that Brandow's proposal was somewhat too narrow. A committee was appointed under the chairmanship of Wilfred Candler of Purdue University. The committee included George Brandow, Pennsylvania State University, Richard Crom, ERS, and Lehman Fletcher, Iowa State University.

In July 1969, the committee submitted a Proposed Hog Industry Subsector Research Program. This proposal envisioned a comprehensive research program in the economics of hog production and pork marketing. It included many more aspects of hog production and marketing than were included in the Brandow proposal.

Wilfred Candler of Purdue and Alden Manchester of ERS were appointed coleaders of the study. In September 1969, they visited several States to explain the nature of the research envisioned and to obtain expressions of interest. Eight States (Illinois, Iowa, Michigan, Minnesota, Missouri, Indiana (Purdue), Texas, and Wisconsin) indicated an interest. It then became evident that funds were not available to support research on this scale. The concept of a comprehensive research program in the economics of hog production and pork marketing was scaled down. The proposal which was approved in February 1970 was for a much more limited but still quite broad effort which involved approximately 10 scientific man-years plus a substantial number of graduate students. The number of participating

parties was reduced substantially to fit the resources available. Research got underway July 1, 1970, and is scheduled for completion this year.

In the meantime, a number of other less ambitious, less expensive, and less widely damned efforts got underway. ERS is conducting a fairly substantial amount of systems research of various kinds which deal with many commodities. Most of these research efforts start with only a portion of the total production-marketing system and are intended to grow gradually to include the entire system. Some of the research efforts utilize cost-minimizing spatial models, while a few others utilize simulation models.

WHY

The business of research economists dealing with commercial agriculture is focused much more than formerly upon the analysis of public policy questions. Increasingly, economic research is called on to provide analyses of the effects of alternative public policies. The policymaker wants to know what the effects are likely to be if he adopts one policy rather than another. In short, the need is for what has been called "futures analysis"--which means nothing but looking ahead. It should be unnecessary to point out that many of the public policy questions are of compelling interest to private parties as well as to the public decisionmakers. The policy problems are not new. What is somewhat different is that we approach them in a different context--their effect on the total economic activity of the industry.

The utility of a subsector/ or system analysis is that it allows the researcher to "try out" alternative policies and pose "if-then" questions without actually tampering with the real-world system. In model formulation, one attempts to isolate and capture in a mathematical model those components of the subsector--technical, economic, and organizational relationships--which affect performance.

The production and marketing system for each agricultural product is a complex set of interrelationships. A change at any point in the production and marketing system will have repercussions throughout the system. Formal models of these systems will permit analyses of the effects of changes in any of the relationships upon other relationships and upon the performance of the entire production and marketing system.

Analysis using such models has only become possible in the last few years. Until quite recently, research in the agricultural industries necessarily was organized in relatively small units, since the methodology was not available to encompass all of the major relationships within an industry in a single analysis. With the development of quantitative techniques and the availability of sufficient computer capacity to handle large problems, it is now possible to analyze at least the most important relationships for an entire industry within the confines of a single economic model.

## GENERAL PURPOSE VERSUS SPECIAL PURPOSE MODELS

The models contemplated in subsector research are, to some extent, general purpose models. The objective is to produce one or more models of a subsector which can be utilized to analyze a number of problems, some of which have not yet been formulated.

Every well-conducted course in research methods teaches that the researcher first identifies the problem to be analyzed and then--and only then--does he select the model. It is obviously relevant to ask whether subsector research as discussed here represents an unacceptable reversal of the conventional wisdom embodied in accepted research procedure.

I would argue quite strongly that we can no longer afford the luxury of a new model for each and every question. If we are to provide policy-oriented research results, it is essential to be

able to provide such information promptly--sometimes within a matter of hours. If we have operating models, even though they may not be the most efficient models conceivable for that particular purpose, we can provide acceptable information when it is needed. Answers from the greatest model in the world three years late will be of no use to anyone. Thus, I see no alternative to the use of general purpose models for a great many policy questions.

That is not to say that, when time permits, we will not construct special purpose models which provide more precise answers to a particular question. In general, however, these will be models of subsystems, designed to deal with specific problems within a relatively small part of the subsector. Subsector models must be designed so that more detailed models of specific subsystems can be inserted (or removed, as required).

Both behavioral and optimal models are needed for different purposes and, at times, for comparison. Behavioral models utilizing simulation techniques provide more insight into the communication process in the marketing system, while optimal models necessarily assume perfect communication. The orientation can be primarily spatial--as in an interregional competition model--or concerned with structural changes in the marketing system.

The chief value of such models is not a comparison between the "real" world and the results of the model, but the comparison between various alternative sets of assumptions within the model. By using

such assumptions, the results of postulated changes in market structure, demand relationships, supply relationships, communication systems, or any other feature of the marketing system can be traced out. This use of models is more nearly consistent with the objective of providing information to decisionmakers on which to base better informed choices between alternative courses of action.

## THE KINDS OF QUESTIONS ERS IS ASKED

Most of the questions that ERS is asked have to do with the effects of alternative policies. Recent questions concern:

--Price support levels

--Support purchase prices for butter, powder and cheese

--Intermarket Class I price differentials

--Alternative pooling plans

--Pricing services on the basis of costs

--Import quotas

--Alternative support policies, e.g., no supports

In each of these questions, information is sought as to the effects of the alternative policies on farm and retail prices, production, consumption, farm income--in the aggregate and by farm size and region--and number and size of producers.

## LESSONS FROM OTHER SUBSECTOR WORK

From other subsector or systems work in ERS, we may have learned a few lessons. One of these is that models for the sake of models are out. The argument for general purpose versus special purpose

models is not to be taken to the extreme. "Better understanding" is too vague an objective for model building. What we are seeking are models which are sufficently specific & detailed to yield useful answers to the policy questions which have been posed.

Model development and data development must go together. This, of course, is very easy to say and very hard to do. However, it is essential. Models without the relevant data are of no use.

A crucial element where more than one agency is cooperating in such a study is a common objective. If all parties have a strong interest in pursuing a common objective or set of objectives, then it is possible to divide up the job and get it done.

From the hog-pork subsector research effort, I believe we have learned at least one thing--there is a tremendous burden in trying to accomplish two objectives: (1) to get some useful research results and (2) to show the way to a doubting profession which by and large does not want to know the way to anything different than it is doing now. This results in a rather large chorus of volunteer commentators, which is not particularly useful.

In some of our efforts, including the dairy work, we have prepared a working paper on economic relationships in the subject industry. This is a statement of what is known and what is not known about the economic relationships in that subsector. This is a time consuming job but very educational for the participants. It is potentially useful if it is used in the long run by researchers in the subsector.

# SYSTEMS ANALYTIC MODEL OF THE DAIRY INDUSTRY

by
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As economists our greatest contribution to policy makers is likely to stem from our ability to make conditional forecasts--conditional forecasts of the outcome of specific possible or actual courses of action on the part of (1) policy makers, (2) participants in the economy of interest, or (3) participants in other economies, and conditional forecasts of the outcome of exogenous changes which may be imposed on the economy of interest. These conditional forecasts are not easy to come by, at least in a period of time as short as we are usually given. What we too often do, I suspect, is use the shaky elasticities we can get our hands on, add some hastily gathered adjustment factors, a few hunches and a prayer or two. As a consequence, the answers we generate are often rather imprecise, the model is so aggregative that only a limited set of questions can be answered, and/or we are incapable of evaluating the trade-offs between competing performance indicators.

Clearly we do not at present have a well-conceived apparatus which can efficiently and accurately assimilate the vast number of relationships characteristic of the dairy industry so as to enable us to make all of the conditional forecasts that would be desirable. I believe it is fair to say the reason is not that we lack the necessary elasticities, data

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* I am indebted to many people for discussions leading to the development of ideas contained herein. I would like to express special thanks, however, to A. C. Manchester and R. F. Fallert.

from which to estimate these elasticities. manpower, or expertise. Rather, I suggest the reason is because we have not yet made a concerted effort to capitalize on our collective knowledge (and ignorance!) of the industry in an attempt to systematically make our individual efforts add up to produce a useful and complete package.

The effort upon which we are embarking here is an attempt to begin the construction of such an apparatus. For want of something better this apparatus will be called a "Systems Analytic Model". Although I do not claim the phrase "Systems Analytic Model," it seems particularly appropriate. A complete model of the dairy industry must represent a collection of <u>subsystems</u>--production, assembly, processing, distribution, consumption, and regulation. Further, to be useful a complete model of the dairy industry must be capable of being used to <u>analyze</u> alternative situations--to produce conditional forecasts.

While the major burden for the development of this model may rest on the shoulders of a few individuals, the final product will undoubtedly be superior if it reflects the best thinking of all of us who have some expertise in this area. ERS will assume a major role in this effort. Nevertheless, research contributions from universities are encouraged and in a few instances have already been pursued.

My purpose in this paper is to provide some initial ideas on the design and content of the model in preparation for workshop discussions. Initially, I discuss what I believe the model should be designed to do--i.e., what questions it should be designed to answer. Second, I outline what I feel is a reasonable procedure to follow in constructing the model. Third, I outline in some detail the basic structure of what will be termed a Phase I model. Finally, I suggest some detail for future incorporation.

POLICY FRAMEWORK

The first step in constructing a model of this nature is to decide precisely what its purpose shall be. In this connection, I find Tinbergen's approach to the theory of economic policy particularly helpful. 1/ To Tinbergen, there is a set of target variables 2/, a set of instrument variables, and "data." The target variables may be considered goals of the policy makers and can be fixed or flexible. The instruments are the means which the policy maker can use, manipulate or influence in order to achieve his targets. The "data" are the uncontrollable or exogenous factors characteristic of the economy. The way in which the instruments and "data" affect the targets is conditioned by the structural relations or constraints of the system.

Finally, in addition to the targets, there may be a set of side effects or "irrelevant" variables in which the policy maker is not interested. But since both targets and irrelevant variables may constitute measures of how well the system performs, I prefer to call them collectively policy variables.

Given this general framework, one can concentrate on measuring impacts on the policy variables or on discovering what conditions are necessary to meet targets. 3/ One might choose, for example, to specify values for the instruments and exogenous variables, then solve the reduced

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1/ J. Tinbergen. On the Theory of Economic Policy. North-Holland, 1956. See also K. A. Fox, J. K. Sengupta, and E. Thorebecke. The Theory of Quantitative Economic Policy. North-Holland, 1966, Chapter 2.

2/ More specifically, there is a welfare function which is a function of the target variables.

3/ I assume here that certain mathematical properties of the system necessary for a solution can be met.

form equations of the system for the resulting values of the policy variables. Indeed, by proceeding in this way, one could trace the impact of a variety of levels of the instruments.

Alternatively, one may desire to impute to the system desired values of the policy variables, then solve the system for the level of the instruments necessary to meet the specified targets. In this way, one can evaluate the policies needed to meet certain targets.

Policy Variables

If we are successful in isolating (or more appropriately anticipating) the relevant policy variables, we will probably be sucessful in formulating a useful model. This set of variables will dictate in large part what shape the model will take.

In order to develop a realistic list of policy variables for the dairy industry, it might be helpful to consider what are likely to be the relevant issues facing the dairy industry in the foreseeable future. This is not the place to dwell at length on these issues but eight are worth mentioning here: 4/

1. What would be the impact of alternative methods for pricing milk and dairy products?
2. What would be the impact of alternative methods of sharing the proceeds of Class I sales among producers in different areas?
3. What is likely to be the impact of the growth and changing role of dairy cooperatives?

4/ This list is not intended to be complete nor is it intended to imply any priorities. It was developed in large part through a series of discussions in which the entire ERS dairy team participated.

4. What are likely to be the impacts of pollution control regulations imposed on producers and processors?

5. What will be the location of milk production in the future, and what will be the impact of changes in the structure and location of milk production?

6. What will be the future location of dairy product processing facilities, and what will be the impact of changes in the structure and location of dairy product processing?

7. What is likely to be the future structure of demand for dairy products and the impact of changes in demand (e.g., increased demand for cheese and lowfat items)?

8. What will be the impacts of supply control legislation and of restrictive (FTC) legislation affecting processing firm operations?

In order to address issues such as the above, it seems to me we should construct a model that is capable of generating information on the following policy variables:

A. Producer related variables.

   1. Number of cows on hand in each region.
   2. Milk production per cow in each region.
   3. Grade A and Grade B milk production in each region.
   4. Size distribution of dairy farms in each region.
   5. Capital and labor use on dairy farms in each region.
   6. Beef production by the dairy industry.
   7. Cost of milk production on farms in different regions.
   8. Net income of dairy farmers by size of dairy herd in each region.
   9. Pollutants produced.

B. Processor-retailer related variables.

1. Wholesale and retail margins by product by region.
2. Size distribution of processing firms by region and by type and ownership of firm.
3. Net income of processing firms by size and type and region.
4. Production and inventories of dairy products by region.
5. Capital and labor use of processing firms by region.
6. Excess capacity of processing firms by region, by season, and by type of firm.
7. Pollutants produced.

C. Consumer related variables

1. Consumption of dairy products by region.
   a. Store sales.
   b. Institutional sales.
   c. School lunch and food stamp sales.
2. Retail prices of dairy products.

D. Government related variables.

1. Purchases of dairy products.
2. Storage costs.
3. Administrative costs of federal order and support programs.

E. Foreign trade related variables.

1. Exports of dairy products.
2. Imports of dairy products.

While not stated in terms of questions to be answered, these are the things about which information should be generated so that the issues listed above can be addressed.

## Policy Instruments

The policy instruments are taken to include those things which are or can be dictated by the regulatory authorities or by firms in the industry. They include:

1. Support price level.
2. Pricing rules or strategies.
    a. Formula pricing.
    b. Component pricing.
    c. Classified pricing.
3. Procedures for pooling milk.
4. Order consolidation.
5. Welfare programs.
    a. Food Stamp.
    b. School Lunch.
    c. Donations.
6. Incentives for change encouraged or dictated (i.e., pollution control, increased productivity, anti-trust activity, etc.)
7. Advertising and promotion.
8. New technological developments in production, processing, and transportation.
9. Foreign trade restrictions and incentives.

## Exogenous Variables

The model should also be responsive to changes that occur outside the system and which are not brought about by the regulatory authority. These variables will affect the policy variables and may dictate in part what action is needed to achieve certain targets. These exogenous variables would include:

1. Shifts in the location of feed production.
2. New technological developments in the feed industry and in genetics.
3. Opening of new alternatives (farm and nonfarm) to dairy production.
4. Changes in the supply of and costs of farm labor.
5. Weather.
6. Changes in the demand for farm land (e.g., pressure for urban expansion)

## MODEL CONSTRUCTION

Our store of knowledge now or even after this workshop is not going to be sufficient to enable us to cope with all the details which will have to be considered. Some details will only be learned as we become more familiar with the data and as we conduct experiments with the model. For example, what is the appropriate level of spatial and product aggregation or what is the appropriate functional form for the demand equations? Furthermore, there is, as I will argue below, some advantage in proceeding in stages.

Hence, I hope that a reasonable degree of flexibility becomes something of a guiding principle in the development of this model--flexibility as to what is modeled when and by whom, what technique is used in a particular part of the model, what are the precise forms of the equations of the system, etc. Indeed, this seems to be the real advantage of the simulation approach as opposed to, say, the rather rigid linear programming or input-output models which are designed to examine a rather limited set or even a single policy variable.

We have tried to adopt this approach in our work so far. For example, what I shall describe below has been dubbed the Phase I model. It is a rather simple formulation of a basic supply-demand model for the dairy industry with sufficient constraints built in to approximate reality in a broad or macro sense. It has limited normative capabilities and by no means includes all policy or instrument variables outlined above.

I see several advantages in operating in this fashion. First, it assures that a model is developed and available at all times--it will not answer all of the questions we may like to ask it nor will it answer these questions as precisely as we would like; but it is available for generating a limited amount of information.

Second, by starting with a relatively simple model and progressing to more complicated ones, we are not as apt to lose sight of the trees for the forest. This has two dimensions--model construction and model testing. Every effort must be made to see that all components of the model are sufficiently detailed and constructed so they are related in a logical and consistent manner. Also, we are likely to find it to our advantage to be able to test out each component of the system on progressively more complex models.

Finally, by progressing in this manner, we will force ourselves to build the model in such a way that it can easily be added onto, revised, and updated. Model formulation is critical but not independent of refinement and testing. Models must be subjected to whatever tests are available to guard against internal inconsistencies or logical errors. "In economics, as in medicine, autopsies can and should be a major learning device." 5/

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5/ Zyi Griliches. "The Brookings Model Volume: A Review Article." Rev. Econ. and Stat. 50:215-34, May 1968.

Halter, et. al. 6/ have suggested a useful conceptual scheme for viewing the modeling process as an iterative problem solving effort in which feedback loops between modeling, estimation, and experimentation are a prominent feature.

## MODEL COMPONENTS

### Regional Demarcation

The previously listed policy variables dictate that the model will be regional in scope. In delineating regions many compromises are necessary. Data limitations make proceeding on other than an aggregation-by-states basis nearly impossible at least in the initial stages. For the sake of manageability, a relatively small number of regions is desirable.

Several possibilities exist here, three of which are shown in the appendix. We have initially chosen what I call the ERS regions. 7/ These were developed, at least in part, with a view toward defining regions which consisted of states between which shipments of milk were known to occur. The Ruane-Hallberg regions, 8/ on the other hand, were developed on the basis of similar production and marketing characteristics -- inter-regional flow characteristics were ignored. Some extra consideration was given to the Northeast, Lake States, and Cornbelt in part because of the extra detail provided by the dairy adjustment studies for these regions.

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6/ A. N. Halter, M. L. Hayenga, and T. J. Manetsch. "Simulating a Developing Agricultural Economy: Methodology and Planning Capability." AJAE 52:272-284, May 1970.

7/ This regional breakdown is due to the ERS dairy team.

8/ J. J. Ruane and M. C. Hallberg. Spatial Equilibrium Analysis for Fluid and Manufacturing Milk in the United States, 1967. Penn State Univ. Agr. Exp. Sta. bulletin 783, Aug 1973.

## Products

The policy variables also dictate that the model incorporate Grade A and Grade B milk production as well as a major product break-down. At a minimum the model should include the following products:

1. Fluid whole milk.
2. Fluid lowfat milk products.
3. Cream.
4. Other fluid products.
5. Butter.
6. Nonfat dry milk.
7. Dry whole milk.
8. Hard cheese.
9. Cottage cheese.
10. Evaporated and condensed milk.
11. Frozen products.

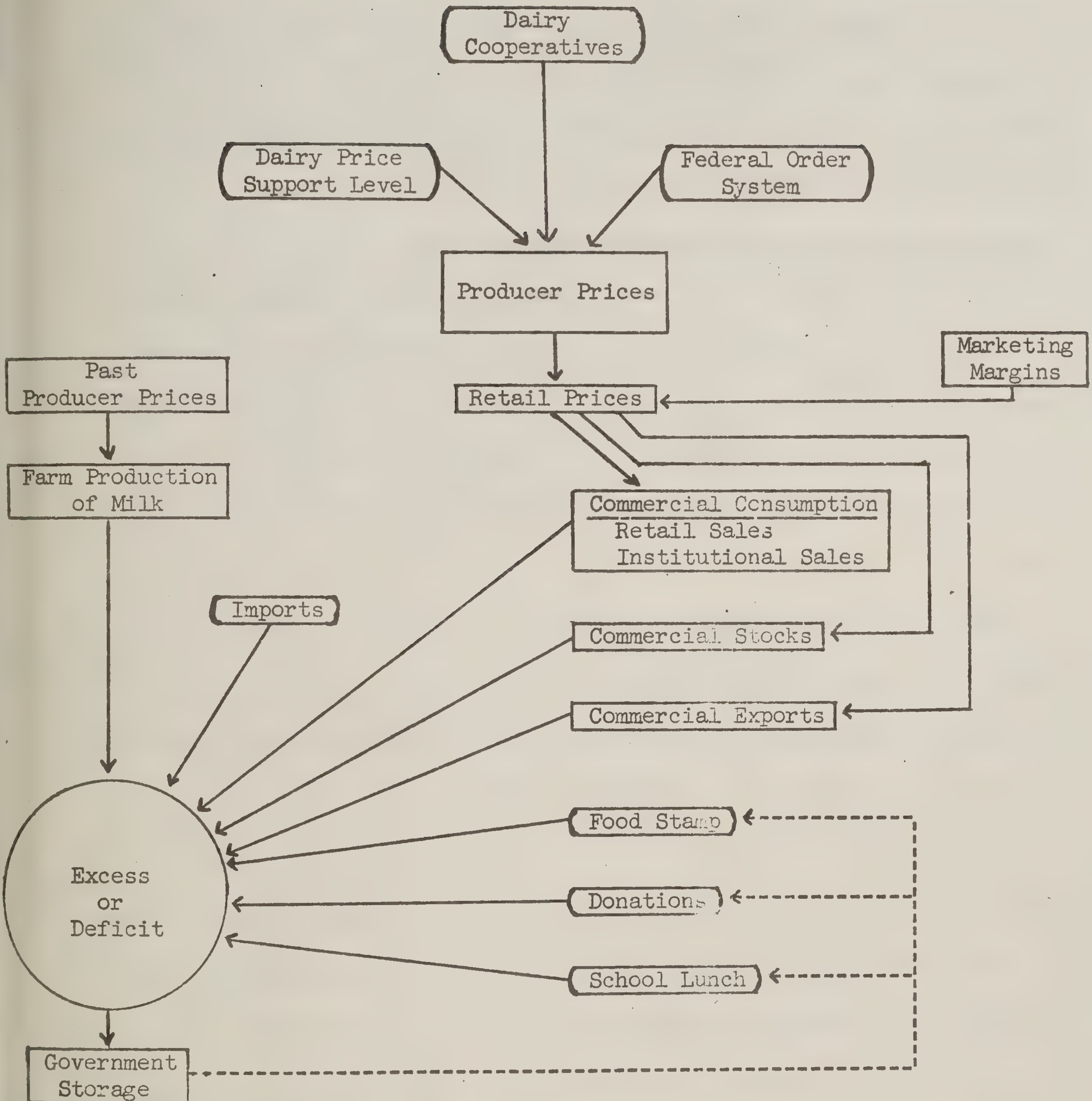
## Time Period

We plan to use the quarter as our unit of observation partly in an effort to include at least some seasonality considerations, partly to be able to aggregate either on a calendar or marketing year basis, and finally so that relatively short-term projections can be made. This clearly has disadvantages. Some data (such as demographic data, heifer calves, etc.) are only available annually so that between year interpolations are necessary. Furthermore, in some cases annual data may be more accurate than monthly or quarterly data. Nevertheless, it would appear that the advantages of using the shorter time period outweigh the disadvantages and that reasonable adjustments can be made for the data limitations.

## Model Structure--Phase I Model

The accompanying figure outlines in a general way the structure of what I would consider the basic supply-demand model. It views the performance of the dairy industry in the following steps:

1. The support level is established by the regulatory authority and support prices for raw milk, butter, powder, and cheese are established.
2. Producer prices are determined on the basis of (1) support prices, (2) general market conditions, and (3) federal order regulations.
3. Given producer prices and marketing margin relations, retail prices are obtained.
4. Given the demand functions, inventory functions, and export functions; quantities demanded, commercial stocks, and exports are determined.
5. Given exports, imports, and donations, the total amount of butterfat and solids-not-fat needed to meet domestic and foreign requirements are determined.
6. Farmers will have responded to historical prices and other factors in deciding how much milk to produce. Total milk production can be translated into butterfat and solids-not-fat production.
7. Now production and requirements of butterfat and solids-not-fat are matched to determine how much butter, powder, and cheese is either purchased or released by USDA in order to carry out the price support program.


Dairy Cooperatives
Dairy Price Support Level
Federal Order System
Producer Prices
Marketing Margins
Retail Prices
Past Producer Prices
Farm Production of Milk
Commercial Consumption
Retail Sales
Institutional Sales
Imports
Commercial Stocks
Commercial Exports
Food Stamp
Donations
School Lunch
Excess or Deficit
Government Storage

Determination of Support Prices

This is simply a matter of following ASCS's procedure of calculating the support price for manufacturing milk, butter, cheese, and nonfat dry milk. The procedure has been outlined and programmed for the computer (see paper by Sleight in this proceedings.)

Determination of Milk Prices at the Producer Level

The determination of producer prices is, in some respects, the most crucial part of the model but is by no means resolvable by a foolproof method. The blend price, $P_B$, (i.e., the price of all milk at wholesale and the price to which farmers will be assumed to respond) can be taken to be a weighted average of the fluid price, $P_F$, and the manufacturing price, $P_M$:

$$(1) \quad P_B = (P_F Q_F + P_M Q_M) \,/\, (Q_F + Q_M)$$

where $Q_F$ = supply of milk going to the fluid market, $Q_M$ = supply of milk going to the manufacturing sector, and $Q_F + Q_M = Q$ = total milk supplied.

But all we know at this point is that:

$$(2) \quad P_S \leqslant P_B$$

where $P_S$ is the support price. We do not know by how much $P_B$ must exceed $P_S$, if at all, nor do we know $P_F$ or $P_M$. And, of course, we will not know $Q_F$ and $Q_M$ until we know $P_F$ and $P_M$.

It is fairly generally agreed that $P_F$ is (ignoring for the moment negotiated premiums) administratively determined. It is also probably fair to assume that administrators attempt to set $P_F$ at a level which will insure a satisfactory and stable producer return yet not so high as to encourage excessive milk output. One possibility would be to specify an arbitrary "administrator's formula" as does Kottke. 9/

9/ Marvin Kottke. "Spatial, Temporal, and Product-Use Allocation of Milk in an Imperfectly Competitive Dairy Industry." AJAE 52:33-40. February 1970.

In point of fact, however, the minimum price for fluid milk is established by federal orders and is set on the basis of some fixed differential, DIFF, from the Minnesota-Wisconsin manufacturing milk price, $P_{M-W}$. The only difference between the federal order fluid milk price and the actual fluid price received by farmers, $P_F$, is negotiated premiums, PREM. Hence:

$$(3)\quad P_{F_t} = P_{M-W_{t-1}} + DIFF_t + PREM_t.$$

For our purposes we shall take DIFF and PREM as purely exogenous factors.

Next we must determine $P_{M-W}$. Here we can assume:

$$(4)\quad P_{M-W_t} = P_{S_{t-1}} + f_4(SEAS,\ S\text{-}D_{t-1})$$

$$(5)\quad f_4(SEAS,\ S\text{-}D_{t-1}) \geqslant 0$$

where SEAS = a seasonal adjustment (e.g., a set of dummy variables representing seasons of the year) and S-D = a supply-demand adjuster. For S-D, several possibilities could be used, including net USDA removals of butter and powder or CCC purchases of butter or powder.

Finally we need to determine $P_M$. Here, I have simply assumed:

$$(6)\quad P_{M_t} = f_6(P_{M-W_t}).$$

The prices determined so far--i.e., $P_F$, $P_M$, $P_{M-W}$-- relate to prices in the Minnesota-Wisconsin area only. To determine regional fluid prices we might use:

$$(7)\quad P_{F_i} = P_F^{Base} - PREM_{Base} + PREM_i + f_8(TRAN_i)$$

where $P^{Base}$ is the appropriate price in the base region (Minnesota-Wisconsin), and $TRAN_i$ is the transportation cost incurred in shipping milk between the base region and region i. Formula (7) recognizes that almost all federal orders in the country base their class prices on the Minnesota-Wisconsin price and also that all milk prices in the country are related

to prices in the Minnesota-Wisconsin region by a transportation cost differential. 10/ Regional manufacturing prices will be taken to be equal to $P_M^{Base}$. This is, of course, not quite true and must be dealt with more realistically in future models.

To determine $P_B$ in all regions we use equation (1). Here I propose to use last period's class I utilization ratio to determine this period's blend price as an initial approximation. Indeed this may be the best possible approximation of the current class I utilization (I do not expect a significant difference in this ratio over a period as short as a quarter). Nevertheless once the demand portion of the model is solved we can infer the fluid demand for regions. Thus we can adjust the utilization percentage and iteratively strike a balance between prices and class I utilization.

Marketing Margin Relations

Explicit margin relations to be included for each product will have the following form:

$$(8) \quad P_R = a + b\,P_f + \sum C_i X_i$$

where $P_R$ = retail price, $P_f$ = farm price, and the $X_i$ are representative of:

1 - labor costs.

2 - transportation costs.

3 - promotion expense.

4 - technology.

These functions will be representative of the entire United States.

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10/ Because of provisions in the orders, there is also reason to expect $P_{F_i}$ to differ from $P_F^{Base}$ because of different class I utilization ratios. In regions as large as we have specified here, this is not likely to be a significant factor.

## Demand Functions

Demand functions to be included in the model will be of the form:

(9) $Q_D = a + b\,P_r + \sum C_i X_i$

where the $X_i$ are representative of such factors as:

1 - income distribution

2 - distribution of population by age groups.

3 - distribution of population by family size.

4 - distribution of population by regions.

5 - distribution of population by urbanization.

6 - promotion.

These functions will be representative of the entire United States. Initially, at least, we will assume $Q_D$ includes retail sales, institutional sales, as well as military consumption.

## Commercial Stocks

The theory with which to explain variations in commercial stocks, S, is not as well received as in other areas of economics. I know of absolutely no research in this area for the dairy industry so that our specification must be taken to be quite tentative.

It seems reasonable to assume that a low retail price for, say, butter will call forth a higher accumulation of butter stocks in the coming period than would a high retail price. But if there is already a relatively large buildup of butter stocks, then there will be a tendency for a lower rate of stock accumulation during the coming period. Hence, if we assume there is some underlying equilibrium level of stocks, we have as the reduced form stock equation:

$$(10)\ \Delta S_t = a + b\Delta P_t + c\ S_{t-1}$$

where $\Delta S_t = S_t - S_{t-1}$, $\Delta P_t = P_t - P_{t-1}$, S = level of stocks in period t, and $P_t$ = retail price in period t.

Stock equations will be representative of the entire United States. There will, of course, be no stock equations for fluid products, cottage cheese, or frozen products.

Commercial Exports

Here again, I am aware of no previous research. Perhaps the best that can be done at this point is to assume that exports are given exogenously.

Imports

Imports will be taken to be exogenously given to the system.

Food Stamp, School Lunch, and Donations

To a certain extent all three of these variables are exogenously determined. However, given that we are going to have the programs, the consumption of dairy products via the food stamp program should be a function of the number of people below the poverty income level and the consumption of dairy products via the school lunch program should be a function of the number of children between the ages of 7-18. Donations by the Government will depend in part on the amount of CCC purchases during the previous periods.

Milk Production

In the Phase I model traditional regional supply functions will be included which have the following form:

$$(11) \quad S_t = a_o + a_1 S_{t-1} + a_2 P^*_{B_{t-1}} + a_3 PG_t + a_4 PB_t + a_5 W_t + a_6 t$$

where:

$S_t$ = regional milk production

$P_B$ = Blend price in region

$PG$ = Price of 16 percent dairy ration in region

$PB$ = price of beef in region

$W$ = farm wage rate in region

$t$ = time

$a_o$ = quarter specific intercept

$P^*_{B_{t-1}}$ = a distribution of lagged blend prices.

In order to be complete here, of course, we must also be able to predict (1) milk fed to calves, (2) milk consumed on farms as fluid milk and cream and butter, and (3) cream sold off-farm so that we can determine the net amount of milk available to milk processors.

Determination of Government Purchases

In order to carry out the support program, the USDA purchases primarily butter, cheese, nonfat dry milk, and evaporated milk. How much of each of these four products USDA purchases is the final question which must be addressed.

Assume we can estimate the total butterfat, $F_r$, and solids-not-fat, $S_r$, utilized to produce those dairy products required to meet all categories of demand already discussed exclusive of USDA donations. 11/ Assume also we can estimate the butterfat, $F_s$, and solids-not-fat, $S_s$, supplied given total milk production. Then USDA purchases of butter, $Q^g_B$, cheese, $Q^g_c$, nonfat dry milk, $Q^g_n$, and evaporated milk, $Q^g_e$, must satisfy:

$$(12) \quad F_s - F_r = f_B Q^g_B + f_c Q^g_c + f_n Q^g_n + f_e Q^g_e$$

11/ Precisely how this can be done will be discussed in detail at the workshop.

$$(13)\quad S_s - S_r = s_B Q_B^g + s_c Q_c^g + s_n Q_n^g + s_e Q_e^g$$

where the $f_i$ and $s_i$ are fat and solids-not-fat content, respectively, of the respective products.

Equations (11) and (12) do not provide enough constraints with which to determine the four unknowns. A reasonable procedure would seem to be to:

$$(14)\quad \text{Max} \quad = N_B Q_B^g + N_c Q_c^g + N_n Q_n^g + N_e Q_e^g \qquad \text{subject to (12) and (13)}$$

where the $N_i$ are estimated net returns to processors from the production of the respective products.

## FUTURE MODELS

As I implied earlier in this paper, I view the model just outlined as a "first approximation" model. It could be used to analyze the impact of changes in such things as dairy import-export policies, support level, or marketing margins on a few of the policy variables listed earlier. Many interesting questions can not be answered, however, because the relevant policy variables are not included in the Phase I model.

In deciding what should be done next, one needs to determine whether he adds detail or improves upon what he already has. For a Phase II model we have chosen to concentrate on adding detail since demands upon ERS require the evaluation of alternative support levels on producer incomes as well as on the policy variables included in the Phase I model. Thus we visualize the Phase II model having the capability of generating information on (1) the size distribution of dairy farmers by the nine regions included, and (2) net income on different sized dairy farms in the different regions. This capability will be superimposed on the existing structure of the model outlined above. In addition, of course, ongoing work designed

to improve existing functional relations will be incorporated as it becomes available. In terms of timing, the Phase II model should be completed by late fall 1973.

Future model phases become more difficult to foresee, but I would suggest that the Phase III model include the following additional features:

1-full regionalization on the demand side (but still undoubtedly with the same price elasticities for each region--i.e., the regional demand functions will only reflect different population distributions and other known demand shifters ).

2-regional marketing margin relations and/or better estimates of processing costs.

3-improvements in supply response and incorporation of a model that will explain regional cow numbers, output per cow, etc.

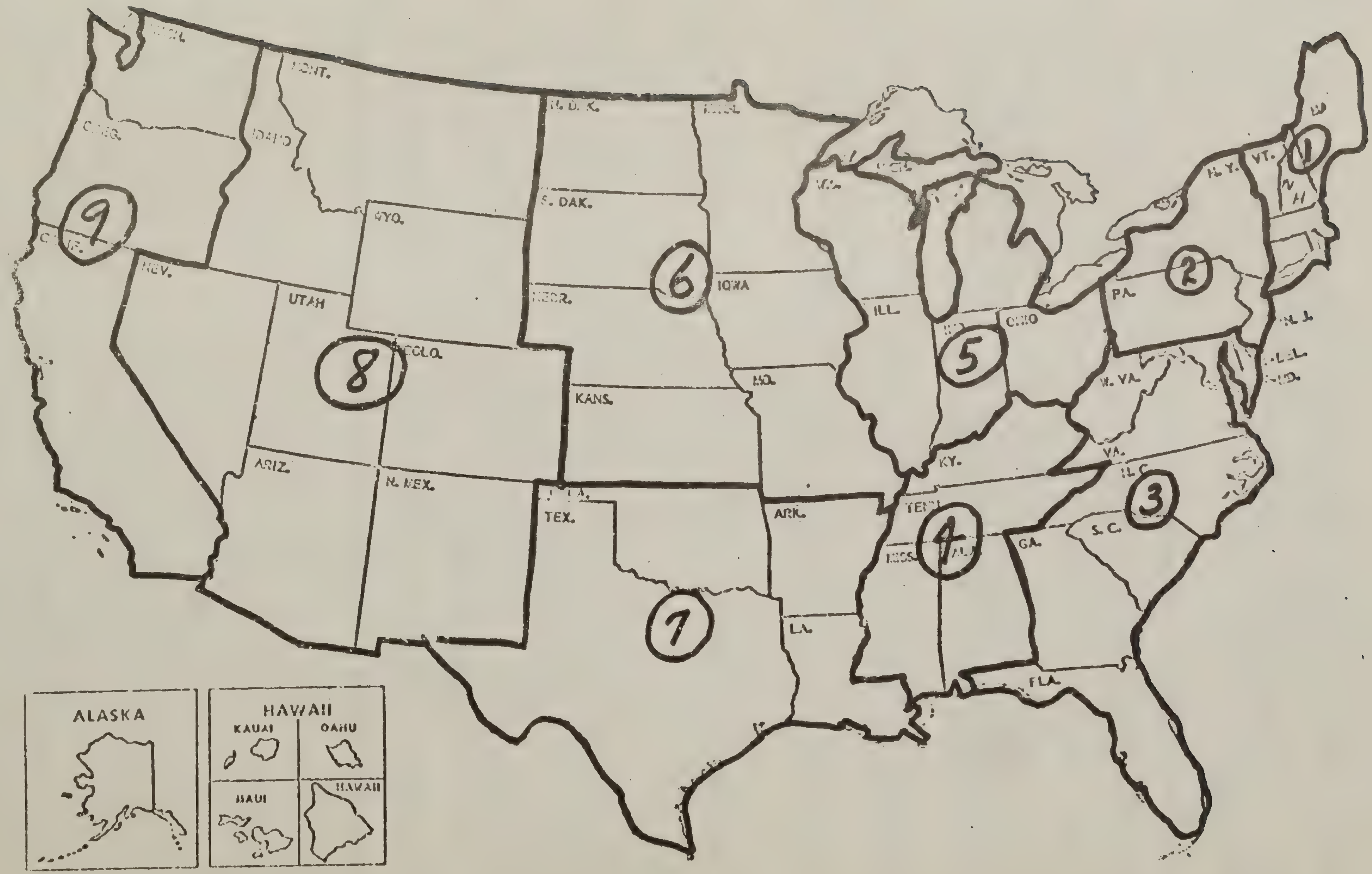
Other details that must be dealt with at some time in the future include:

1-a mechanism for dealing with the question of intermediate products -- i.e., butter, nonfat dry milk, fluid milk, condensed milk, etc. used to produce ice cream.

2-mechanism for generating size distribution of processing plants and returns to processing.

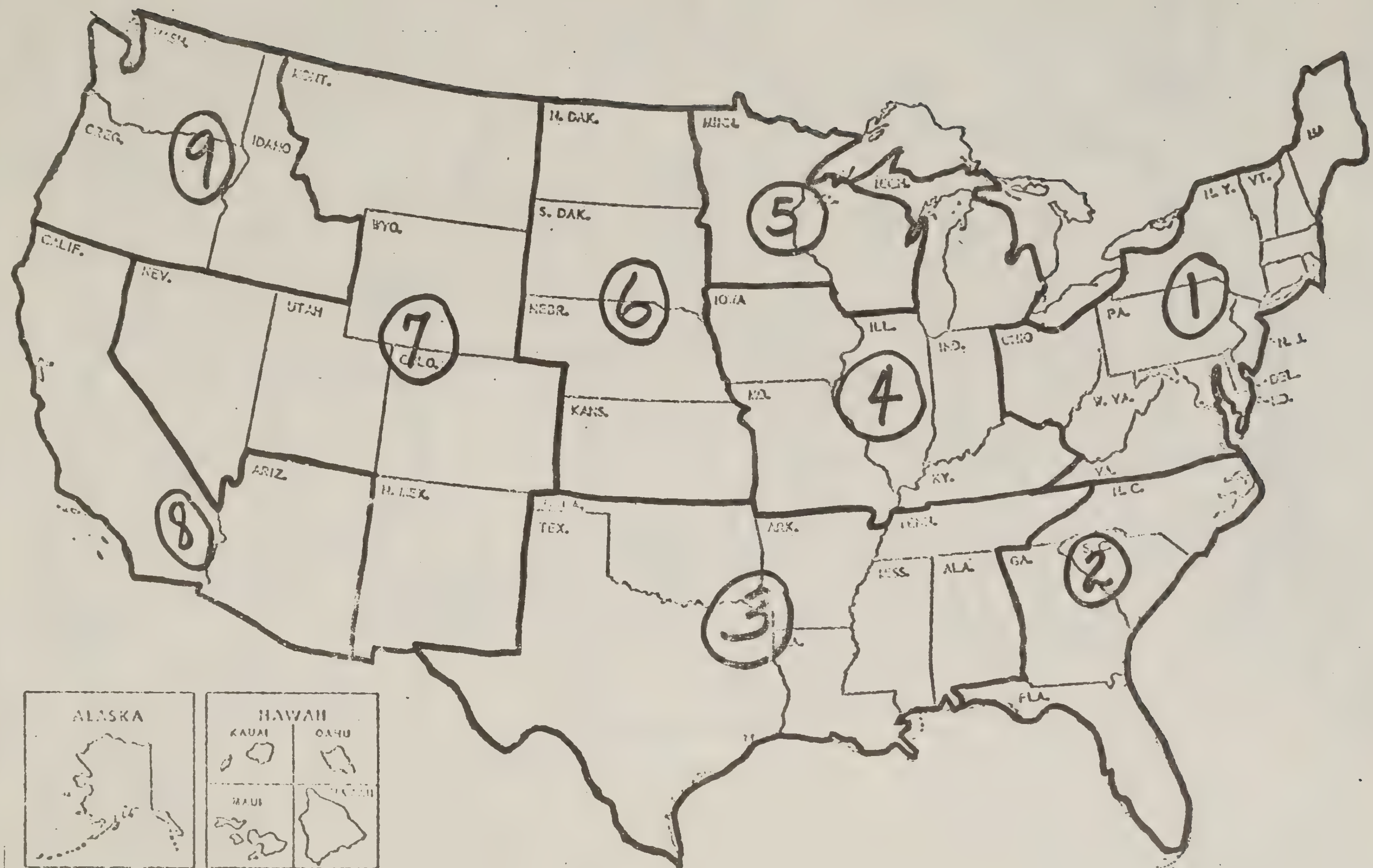
3-a method for incorporating the changing role of cooperatives.

4-a method of isolating questions relating to vertical integration.



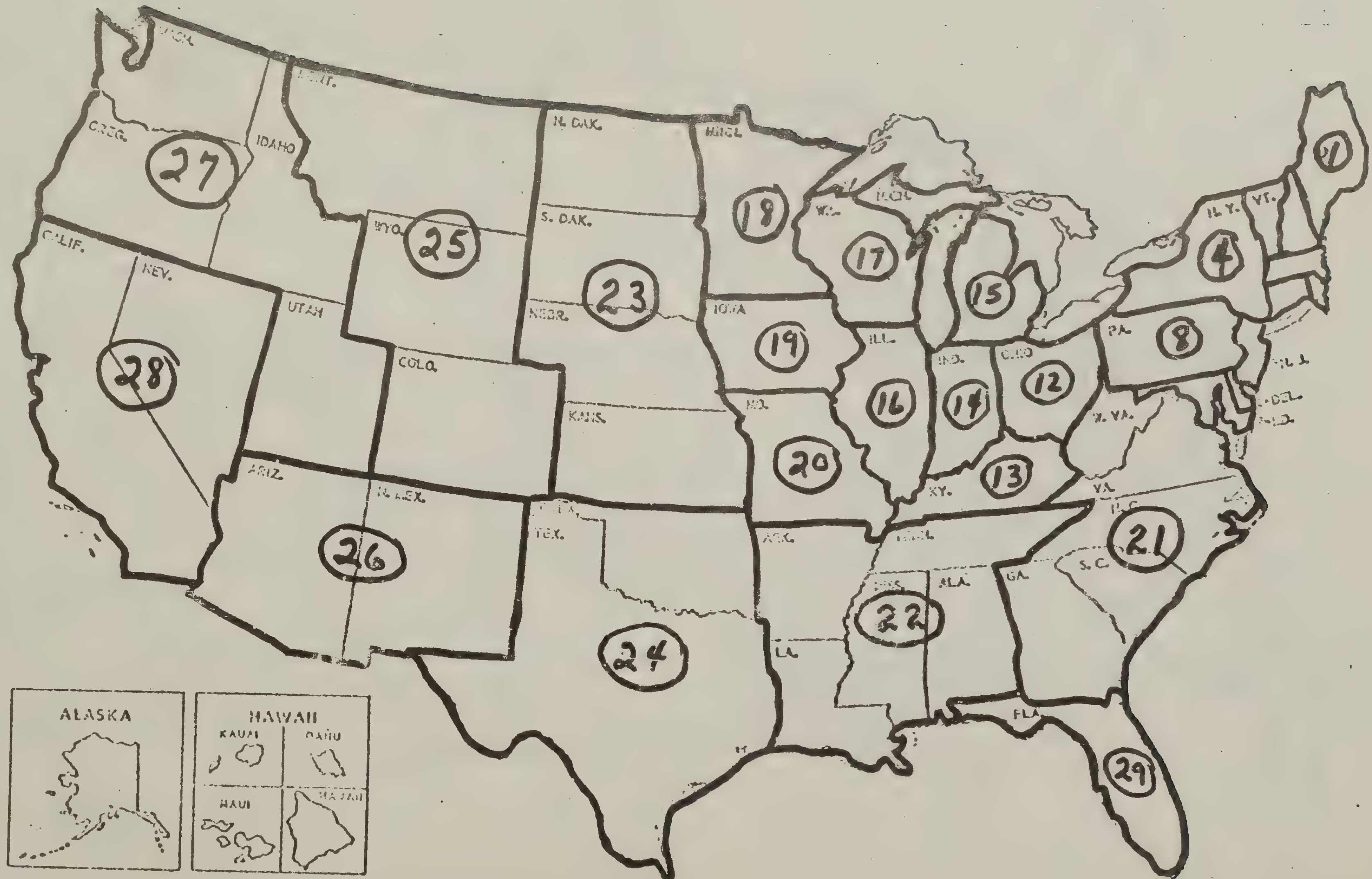

AD-401.2

CENSUS REGIONS




AD- 401.2

ERS-FPED REGIONS




AD-401.2

RUANE-HALLBERG REGIONS

# Government Constraints on the Dairy Industry System

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My assignment is to discuss constraints placed on the dairy industry system by government. We all can identify the government activities that are relevant to the dairy industry, but I think it would be helpful to review the manner in which the industry is affected. Activities I will discuss include Federal milk orders, merger moratoriums, price supports and commodity distribution.

## Federal Milk Orders

A fundamental question in developing a dairy industry model is whether the model should accurately represent the real world system. I think it should, at least in the beginning. One reason is that the validity of the model rests in part in its ability to duplicate past data. Another reason is that the model will be used to derive recommendations for adjustments in the real world system. It would be difficult to demonstrate the advantages of a recommendation unless a comparison is made to model performance without the adjustments. For comparison we need a model that faithfully reflects real relationships.

Here are some aspects of the Federal order system that should be kept in mind as the model is developed:

1. Advance Class I pricing. Class I prices in all Federal milk orders are set by adding a fixed differential to the Minnesota-Wisconsin price for the second preceding month. This means that the difference between current Class I prices and current manufacturing milk prices is not fixed. If

manufacturing milk prices are rising, then the Class I differential is smaller than the amount stated in the order. If manufacturing milk prices are declining, then the Class I differential is larger than the stated amount. Since manufacturing milk prices have been rising and are likely to continue to rise, milk producers realize smaller returns from the Class I market than they would under a price formula with less lag between manufacturing milk prices and Class I prices.

It would be difficult to accurately reflect advance Class I pricing in a quarterly model of the dairy industry. The basic formula for the Class I price for the current quarter is the average Minnesota-Wisconsin price for the last two months of the preceding quarter and the first month of the current quarter. It would be a little easier to handle with a monthly model since there would be no need for averaging.

2. <u>Structure of manufacturing class prices</u>. Some Federal order markets use the current Minnesota-Wisconsin price to set manufacturing class prices. Other markets use a butter-powder formula price, while still others use the lower of the two. The difference between these two prices can be large at times, so manufacturing class price relationships between markets will change from month to month.

Variation in manufacturing milk prices under Federal orders is just one manifestation of variation in manufacturing milk prices throughout the dairy economy. Most models of the dairy industry either assume no regional variation in manufacturing milk prices or they assume variation is a function of transfer costs from the upper Midwest. As a matter of fact, manufacturing milk prices do vary markedly from place to place and are negatively related to distance from the upper Midwest. Probably much of this variation could be explained by differences in the structure

and density of manufacturing milk production and processing but the research effort needed to find out would be large. At a minimum, I suggest that the model account for different manufacturing milk prices under Federal orders.

3. Structure of Class I prices. The structure of Class I prices under Federal milk orders is fixed by regulation. The Class I differential stated in any order can be changed only through the hearing process. Consequently, Class I price relationships among markets are quite rigid. It is an important question, however, as to what the most desirable Class I price structure should be to maximize competitive efficiency in the dairy economy. We have heard suggestions ranging from uniform Class I prices everywhere to a rigid structure based on distance and shipping costs from the upper Midwest.

In considering Class I price structure, we should remember that Class I prices have only an indirect effect on the allocation of producer milk supplies among markets.

The Class I price structure has a direct effect, however, on the incentives for bulk transfers between markets and for movements of packaged milk. Inter-order transfers of bulk milk for fluid use are allocated pro rata to the utilization of the receiving market or receiving handler, whichever is less. Part of a load, then, is allocated to the manufacturing class. The receiving handler is credited with this utilization, so he will prefer to import milk only when the delivered cost is less than the local blend price. The shipping handler must account to his local pool at local class prices for the utilization assigned in the receiving market. A shipping handler cannot profitably sell milk out-of-market unless the

difference in Class I prices is large enough to cover the cost of shipping both the Class I portion and the Class II portion of the load. This means that Class I price differences must be greater than the cost of shipping a hundredweight of milk. How much greater depends on the utilization in the potential receiving market. Defining a desirable Class I price structure becomes a difficult problem. Equilibrium Class I price relationships depend on utilization percentages as well as shipping costs.

The current standard provision for allocating bulk transfers of milk was adopted as a result of the Supreme Court decision in the Lehigh Valley compensatory payment case in the early 1960's. It may satisfy the legal requirements of that decision, but I suspect that it imposes an economic burden on the dairy industry. Hopefully, the dairy industry model can be used to test alternative transfer and allocation provisions.

The Class I price structure also defines the competitive environment for the movement and sale of packaged milk. The possibilities range from uniform Class I prices to Class I price differences that fully cover transfer costs. Uniform Class I prices would lead to geographic monopolies and tend to minimize distribution costs. If Class I price differences fully cover shipping costs, then a handler at any location potentially must compete with any other handler located between him and the basing point in the upper Midwest. Such a price structure leads to distribution areas skewed away from the basing point, resulting in a larger transportation bill for milk distribution. Certainly, the most efficient Class I price structure for milk distribution is not the most efficient for milk procurement. I hope it is clear that the Class I price structure incor-

porated in the model must be based on careful analysis.

4. Structure of blend prices. The blend price provides the incentive for allocating milk from farms among markets. A dairy farmer will attempt to sell his milk in the market that offers the highest blend price, net of hauling costs. Over time, adjustments in shipping patterns take place so that blend prices seek an equilibrium alignment. This alignment tends to reflect blend prices in the upper Midwest plus shipping costs.

To confuse the matter of blend price alignment we need only introduce seasonal payment plans and Class I base plans. Given the opportunity to ship milk to a market with no seasonal payment plan or to a market with a Louisville payment plan, a producer would benefit from shipping to the Louisville plan market during the pay-out months and to the other market during the pay-in months. There is little evidence that individual producers switch markets in this manner, but cooperatives do occasionally profit from astute shifts of producers among markets. To avoid burdensome complexity in the model, it may be best to ignore seasonal payment plans.

It is an open question as to what constitutes rational behavior for a producer under a Class I base plan. A Class I base market has no market blend price guiding producer response and the cash value of base tends to lock in existing producers and lock out other potential producers for the market. I feel that a Class I base market is effectively separated from the blend price system for allocating producer milk supplies.

To summarize the price alignment problem, we must make separate provisions for price incentives for the movement of bulk plant milk, packaged milk, and producer milk.

5. Pooling provisions. Federal milk orders require minimum association with the Class I market for participation in the pool. These provisions do not become restrictive except in a few markets that carry large reserves of milk. In most markets, a manufacturing plant with a supply of Grade A milk can easily find a Class I outlet large enough to pool the plant. To qualify for pooling in Michigan, Wisconsin, Minnesota, and Iowa sometimes requires a complicated set of hauling and transfer arrangements. Carrying out these arrangements costs money, and the final result is the same as if the milk had never moved or changed hands. Clearly, in some instances in a few markets, pool plant requirements add to industry costs without enhancing industry performance. Unfortunately, neither the dairy industry nor the government has developed a method for identifying milk available to the Class I market without actual performace of a pooling ritual.

The relevant point for the dairy industry model is that pooling provisions do not effectively limit the volume of milk associated with any market. If market participants take full advantage of pooling provisions, additional milk can be associated with nearly any market to the point where Class I utilization is below 25 percent. Also, the Department usually takes a sympathetic view toward pooling problems. As cooperatives and handlers face difficulty in maintaining pool status the Department more often than not will liberalize order provisions. I think pool plant requirements can be ignored in the model.

The question of pooling brings up the question of individual market organization. Distributing plants can be supplied either by direct shipped milk from the farm or by Class I transfers from supply plants.

In a large market a system of supply plants can reduce the total transportation bill for the market because shipments from the country can be limited to Class I needs at distributing plants. With a direct-shipped supply system, all milk goes to the distributing plant, including daily and seasonal surplus not needed at the distributing plant. Hauling must be paid on the movement of this surplus milk to the distributing plant and further hauling is incurred if the milk is moved elsewhere for manufacturing. My suggestion here is to allow for systems of supply plants in the model.

6. Systems of markets. Federal milk order markets are closely interrelated. Sales and procurement areas overlap and sets of markets share in common reserve supplies. Each such set of markets comprises a system, and there is more than one system. Identification of separate systems is important to avoid unreasonable links between markets. For example, few of us would require the Puget Sound blend price to be linked to the Minneapolis-St. Paul blend price by transportation costs. But most of us would be willing to link the Boston market to Chicago. In my view, this would be an error.

To identify systems of markets, I would first identify standby reservoirs of Grade A milk and then identify the markets that make use of each reservoir, either directly or through ties to other markets. I think there are three standby reservoirs of Grade A milk: Northern New York-Vermont, Minnesota-Wisconsin, and Southern Idaho. The northeastern reservoir serves the needs of the New York-New Jersey, Boston Regional, Connecticut, and Mid-Atlantic markets. Price relationships in this area should be based on prices in Vermont. The second system of markets, and by far the largest, shares in the Minnesota-Wisconsin

reservoir and includes all other markets east of the Rocky Mountains. It also includes the Mid-Atlantic market. I think this market fits into both the northeastern system and the central America system, and provides a link between the two systems. Prices in the central America system of markets should be tied to the upper Midwest.

The third system of markets should include the Western markets not included in the central America system. Eastern Colorado should be in both systems.

These statements about systems of markets are not based on systematic analysis. They are based on several years of casual observation of price relationships and intermarket movements of milk. Some of you might describe systems of markets differently than I have.

7. Reserve milk supplies. Adequate supply of a fluid milk market requires that sufficient Grade A milk be available to meet fluid demand at all times. This means that extra Grade A milk is available to the market at all times except when demand is greatest relative to supply. Fluid demand varies greatly from day-to-day during the week, and from month-to-month throughout the year. The supply of producer milk varies little from day-to-day but is subject to large seasonal swings.

Based on seasonal indices given in the appendix, the Federal order system needs about 17 percent seasonal reserve. The requirements for individual markets are greater because of less than perfect coordination of milk supplies among markets. Daily variations in Class I demand add at least 20 percent to the all market reserve requirement, if the system can handle a two-day inventory of raw milk. If less than a two-day inventory can be handled by the system, then even larger reserves are

necessary. These estimates are based on average seasonal and daily variations over all markets, implying optimum daily coordination among markets.

The point is that these reserve requirements must be met and must be provided for in the model. It is not sufficient to allocate milk among markets only on the basis of Class I needs. Obviously, these estimates of reserve requirements overstate the reserve milk actually carried by many markets. The reason is that the reserve requirements for individual markets are often carried by other markets in the system. Now, the question arises as to how to allocate reserve requirements for the marketing system among individual markets. Fortunately, the price structure incorporated in the model can provide an automatic mechanism for accomplishing this end. Blend prices must meet one set of structural requirements and Class I prices must meet another. Given the systemwide need for Class I milk and the custemwide supply of producer milk, blend prices and Class I prices in each individual market can be determined. The relationship between the Class I price and the blend price in an individual market establishes the utilization percentage and the amount of producer milk to be associated with the Class I sales in that market. Consequently we can come up with a rational explanation of why 90-percent Class I utilization in Florida can be too low or a 50-percent utilization in Chicago can be too high.

## Merger Moratoriums

The major dairy companies in the U.S. are restricted from expansion in the dairy industry as a result of merger moratoriums and consent decrees resulting from anti-trust litigation in the 1960's. These restrictions on structural adjustments in the industry may be necessary for competitive reasons, but they have undesirable consequences as well.

The dairy processing industry suffers from chronic overcapacity resulting in low margins, poor capitalization and numerous bankruptcies. A factor contributing to overcapacity is the lack of opportunities to exit the industry other than through bankruptcy. A small, underfinanced and technically obsolete handler, has few choices when he realizes he should no longer be in the business. He can sell out, if he can find a buyer. But potential buyers in the dairy industry are scarce and most have similar financial problems. Large organizations that could profitably absorb the business are prohibited from making acquisitions. The specialized nature of dairy facilities and equipment make sale outside the dairy industry very difficult. The final and often the only alternative is to minimize personal losses by working the dairy plant to the bitter end--into bankruptcy.

Another desirable structural development is retarded by limitations on big dairy companies. Given modern processing and distribution technology the performance of the industry could improve with greater specialization of plants. Some plants would produce only main line items like half gallons and and gallons of homogenized milk and skim milk. A smaller number of other plants would specialize in the minor products and container sizes, serving the distribution needs of a number of main line plants. Such an organization requires close coordination among plants. This coordination is not easily achieved among independents, and might best be developed through merger of independents with larger companies. This cannot be done with the current prohibitions on mergers and acquisitions. One result of the restriction on mergers by large dairy companies has been retail chains grabbing off of the main line business in captive dairy plants, leaving the crumbs of the

business to the traditional dairy processors.

You can see that restrictions on mergers and aquisitions limit the structural adjustments that can take place in the dairy industry. As work on the model goes forward, attempts will be made to identify desirable structural adjustments. In doing so, adequate provisions should be made for merger restrictions on big dairy companies.

The merger moratoriums and consent decrees expire after ten years. What are the opportunities for adjustments after expiration? The Kraftco consent decree with the FTC expired last fall. The FTC made it clear to Kraftco, however, that any activity similar to that leading to the original complaint would be closely examined and vigorously prosecuted, if necessary. I suspect that Kraftco will hesitate to make external structural adjustments in the dairy industry.

The conclusion I draw is that the dairy industry will continue to be constrained by antitrust concerns of the FTC and Justice Department.

<u>Price Supports</u>

A basic component of the pricing system in both the real world and the dairy industry model is the dairy price support program. Given the present legal requirements that the price of milk be supported at a level between 75 and 90 percent of parity, and the current phobia about food prices, we can expect supports to remain at 75 percent of parity over the near future. Given the level of support, the actual support price can be projected within a reasonable range. The factors entering the support price calculation are (1) the ten year average all-milk price, (2) the ten-year average index of prices received by farmers, (3) the most recent index of prices paid by

farmers, and (4) the ten-year ratio of manufacturing milk prices to all-milk prices. The ten-year average milk price is rising because each year a low average price from ten years ago is replaced by a high average price from the current year. The ten-year average index of prices received by farmers is difficult to project, but we do know that over the long run this index rises very slowly. The spectacular rise in the last six months should prove to be an aberration. The index of prices paid by farmers rises directly in line with the Consumer Price Index, so reasonable estimates can be made for different rates of inflation. The final factor, the ten-year ratio of manufacturing milk prices to all milk prices is rising. The difference between the two prices has remained steady at about a dollar, while the scale of milk prices in general has risen. Hence, the ratio also rises.

Projecting the support price is a manageable problem under present circumstances. However, the Administration has requested elimination of the 75-percent of parity floor under the support price, and appears willing to ease import restrictions on dairy products. If these two things come about, projecting the support price will become difficult, indeed.

Commodity Distribution

There has been a tendency in recent years to consider the domestic commodity distribution activities of USDA as a dependable source of demand for dairy products. It appears to me, however, that USDA is not willing to buy large amounts of dairy products on the open market for distribution. As long as CCC acquires dairy products under the support program, distribution channels are well supplied. But when CCC purchases decline and inventories disappear, as occurred last fall with nonfat dry milk, the Department seems

reluctant to go into the open market. So far we have little experience with scarcity of dairy products for distribution, and it is possible that humanitarian concerns will result in a policy to keep the distribution pipeline full through open market purchases. On the other hand, domestic commodity distribution programs can absorb more than three percent of the total milk supply. With open market prices above supports, purchases of this magnitude could drive prices above politically comfortable levels. I suggest that distribution programs not be considered a dependable source of demand for dairy products.

# Appendix

Seasonal index of average daily delivery per producer, comparable Federal order markets, 1965-1969.

| Month | Index |
|---|---|
| January | 98.2 |
| February | 100.6 |
| March | 102.9 |
| April | 108.0 |
| May | 111.1 |
| June | 108.1 |
| July | 97.6 |
| August | 94.6 |
| September | 95.1 |
| October | 94.7 |
| November | 93.6 |
| December | 96.1 |

Seasonal index of in-area sales of fluid milk, comparable markets, 1963-1972

| Month | Index |
|---|---|
| January | 103.3 |
| February | 104.3 |
| March | 103.1 |
| April | 101.8 |
| May | 98.3 |
| June | 92.5 |
| July | 91.8 |
| August | 93.0 |
| September | 102.7 |
| October | 104.6 |
| November | 103.1 |
| December | 101.5 |

Daily index of in-area sales of fluid milk, comparable Federal order markets, 1963-1972.

| Day | Index |
|---|---|
| Sunday | 7.3 |
| Monday | 124.2 |
| Tuesday | 102.4 |
| Wednesday | 99.8 |
| Thursday | 106.4 |
| Friday | 125.7 |
| Saturday | 134.2 |

# Determination of Support Prices for Milk and Manufactured Dairy Products*

by
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Economic Research Service
United States Department of Agriculture

Dairy support prices are expressed both as (a) a support price for all milk wholesale at average test or milkfat in farm separated cream and (b) as support purchase prices for cheese, non-fat dry milk, and butter calculated to yield in the marketplace the announced support price for all milk wholesale and milkfat in cream above. The basis for supporting dairy prices is the concept of "parity," the ratio expressing the relative price well-being of dairy producers between prices received and prices paid. Using the parity concept, a "parity price" is developed and price support activities are geared to some specified level of parity. Current legislation requires supports to be between 75 and 90 percent of parity. Mandatory support of milkfat in cream was dropped from legislation starting April 1, 1971.

Several concepts and steps are involved in calculating support prices. The "parity index" ,PI, is the ratio of (1) the current general level of prices for articles and services

* The symbols used in the text are the names associated with the respective variables as coded in a FORTRAN program designed to calculate the support prices under various support levels.

farmers buy to (2) the general level of such prices during the period 1910-14. This index is calculated by the Statistical Reporting Service and is published monthly in "Agricultural Prices."

The "adjusted base prices" for milk ,APBPM, and for milkfat ,ABPF, are calculated by finding the ratio of (1) average prices received for all milk wholesale and for milkfat in cream over the preceding ten years to (2) the average of the indexes of prices received by farmers in the preceding ten years. This is calculated for milk and milkfat and published monthly in "Agricultural Prices".

The "parity price" for all milk wholesale ,PPM, and for milkfat in cream ,PPMF, is found by multiplying the adjusted base price by the current parity index. This is the price which, if received, would give milk producers full price parity between what they sell and buy. It is calculated monthly and published in "Agricultural Prices".

The "support price" is determined by multiplying the parity price by a predetermined level of parity ,SLAM and SLMF, expressed as a percentage of full parity. This gives the announced support price for all milk wholesale ,PSM, and for milkfat in cream, PSB.

Within the dairy price support program, additional calculations are necessary since the program operates through purchase

by the Commodity Credit Corporation of butter, cheese, and non-fat dry milk (plus other products at times) at announced purchase prices, the result of which is calculated to support, in effect, milkfat and all milk at the announced support prices.

In moving from the all milk support price to support purchase prices for individual manufactured commodities, the fluid component of milk is bypassed and the programs deal only with manufacturing grade milk. The "parity equivalent price" for manufacturing grade milk ,PEPM, is calculated by dividing the price received by farmers for manufacturing grade milk by the all milk wholesale price and multiplying the resultant ratio by the parity price. It is not a support price as such, but only an administratively calculated equivalent. It is published in "Agricultural Prices".

In calculating support purchase prices for CCC purchases, ASCS determines, administratively, allowances for the costs of manufacturing each product ,PMB, PMC, PMN. These are commonly referred to as "make allowances", and they change as newer information becomes available upon which to base the determination.

To determine the "support purchase price" for <u>non-fat dry milk</u> ,SPPN, the make allowance PMN is added to the announced support price for all milk wholesale to give a gross value ,GVN, to be covered by the values of the components. The value of the butterfat component of whole milk ,VBN, is subtracted out of gross value by multiplying the yield of butter ,YBN, per cwt. of milk times the wholesale price of butter ,PWB. This leaves

a value for the non-fat component per cwt of milk ,VNN. When the yield factor for non-fat dry milk ,YFN, per cwt. of milk is divided into this value, the value per pound of non-fat dry milk ,SPPN, is found. This becomes the announced support purchase price, a price which will yield the announced all milk support price for milk used in nonfat dry milk.

To determine the "support purchase price" for cheese ,SPPC, the cheese make allowance PMC is added to the announced support price for all milk to give a gross value ,GVC, to be covered by the values of the components. The value of whey fat ,VBC, produced in making cheddar cheese is determined by multiplying the yield of whey fat ,YWF, per cwt. of milk times the wholesale price of butter ,PWB. This value is subtracted from the gross value ,GVC, to give the cheese value per cwt. of milk ,VCC. When this value is divided by the yield factor of cheese per cwt. of milk ,YFC, the value per pound of cheese ,SPPC, is given. This becomes the support purchase price of cheese, a price which will yield the announced all milk support price for milk used in cheese.

The "support purchase price" for butter ,SPPB is calculated by expressing the announced support price of butterfat in terms of pounds of butter by multiplying the support price times the factor for pounds of butterfat, YBB, per pound of butter, .82. To this value is added the make allowance PMB for butter to give the support purchase price per pound of butter ,SPPB, a price which will yield the announced support price for butterfat in cream.

# ACCOUNTING FOR BUTTERFAT AND NONFAT MILK SOLIDS IN THE DAIRY INDUSTRY

by

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Unstandardized producer milk in 1971 contained approximately 3.67 percent fat and 8.60 percent solids-not-fat. Accounting for milk on the basis of either product pounds or milk equivalent (butterfat basis) has generally been the procedure in the past. Generally, the skim milk or solids-not-fat portion of milk has been deemphasized--both from the standpoint of value and utilization. Butterfat has been the most valuable component of milk. Conversion factors based on fat solids alone have generally been used because most of the fat solids were used for human consumption and payments to farmers were based largely on fat content. Solids-not-fat in whey and buttermilk--byproducts of the butter and cheese industries--have not been recovered to any great extent. The picture is changing, however. Tastes and preferences of consumers have changed and are continuing to change. Their want patterns are reflected in an increasing demand for protein and a decreasing demand for fat. In turn, both the price support and Federal milk order programs have been shifting the value from fat to solids-not-fat. 1/

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*/ Appreciation is extended to Milton Hallberg for helpful suggestions.
1/ Examples are: Shifts in price support program to solids-not-fat value relative to butterfat value; lowered butterfat differentials and downward classification of creams and mixtures in Federal Orders.

In determining the quantity of milk required for the production of manufactured dairy products on a solids-not-fat basis, the byproducts associated with the major products (primarily butter and cheese) must be considered. In turn, byproducts (primarily whey and buttermilk) can be used in production of other products or they can be further processed in order to salvage the butterfat and/or solids-not-fat. 2/ Recovering the solids-not-fat from whey and buttermilk appears to be close to a break-even proposition under today's technology and price structure. Environmental considerations are undoubtedly causing more interest in solids-not-fat recovery than either demand pull or profitability. Nevertheless, this is one aspect of the modeling or simulation process that can be dealt with only by considering both the butterfat and solids-not-fat aspects of the dairy industry.

In looking to the future, it appears that further shifts in the milkfat-nonfat milk solids demand and value relationships are on the horizon. Not only will the demand and value relationships be changing , but there will continue to be alternative sources of milkfat, nonfat milk solids, and substitute fats and nonfat solids.

One of the major substitutes in the fat-protein complex is the soybean. Margarine substitution for butter is a well-known phenomenon. Approximately 17 percent of margarine is liquid--commonly skim milk either in fluid form or nonfat dry milk reconstituted with water. Milk solids nonfat comprise about 1.5 percent of margarine's finished product weight. There is evidence, however, that with the rising cost of nonfat

2/ In 1971 approximately 14 percent of the solids-not-fat and 2 percent of the butterfat sold to plants and dealers was accounted for in whey and buttermilk. Most of the butterfat was recovered and utilized to manufacture whey butter, but a large proportion of the solids-not-fat is still going unrecovered.

milk solids much of this outlet may be taken over by soy proteins or dry meatfat.

The extent of fortification of fluid milk products in the future with nonfat milk solids is also open to question. Increasing costs of nonfat solids and changing tastes and preferences of consumers will have an impact here.

In any event, changing standards for fluid milk and manufactured dairy products, changing relative value of milkfat and nonfat milk solids, changing costs of milkfat and nonfat milk solids substitutes, changing technological developments, and changing tastes and preferences of consumers all point to an increasing importance of the nonfat milk solids portion of milk relative to the butterfat portion. Thus, it is argued here that a model or models of the dairy industry must consider both the milkfat and milk solids-not-fat sides of the industry. It is hypothesized that milk will be considered more and more as a source of raw ingredients for further processing into both dairy and non-dairy products than in the past.

## Procedure for Determining the Utilization of Butterfat and Nonfat Milk Solids

In this paper, a method is suggested by which one can determine the total amount of butterfat and solids-not-fat utilized in the production of all products of the dairy industry. The purpose in devising such a procedure is twofold. In the first place, a model of the dairy industry must include a mechanism for assuring that all butterfat and all solids-not-fat actually produced (or more precisely sold to plants and dealers) is accounted for even if some fraction is wasted. Secondly, the model must have some basis for specifying how much butterfat and solids-not-fat remaining after domestic and export demand is satisfied must be purchased by U.S.D.A. and in the form of what products.

The method devised is subject to several limitations. First, the basic data is, in most cases, estimated, so the end result is never definite. Secondly, in dealing with broad aggregates it is necessary to work with arbitrary commodity groupings--unreal input-output coefficients. Also, not all of the data needed is available and must be "manufactured" through the use of reasonable assumptions. Nevertheless, I feel that the procedure suggested is sufficiently accurate to serve the purpose for which it is intended until such time as sufficient information becomes available with which to make substantial improvements.

The schematic shown in the attached figure indicates in a general way what variables and relationships must be considered in developing such an accounting method.

Butterfat and Milk-Solids-Not-Fat Accounting

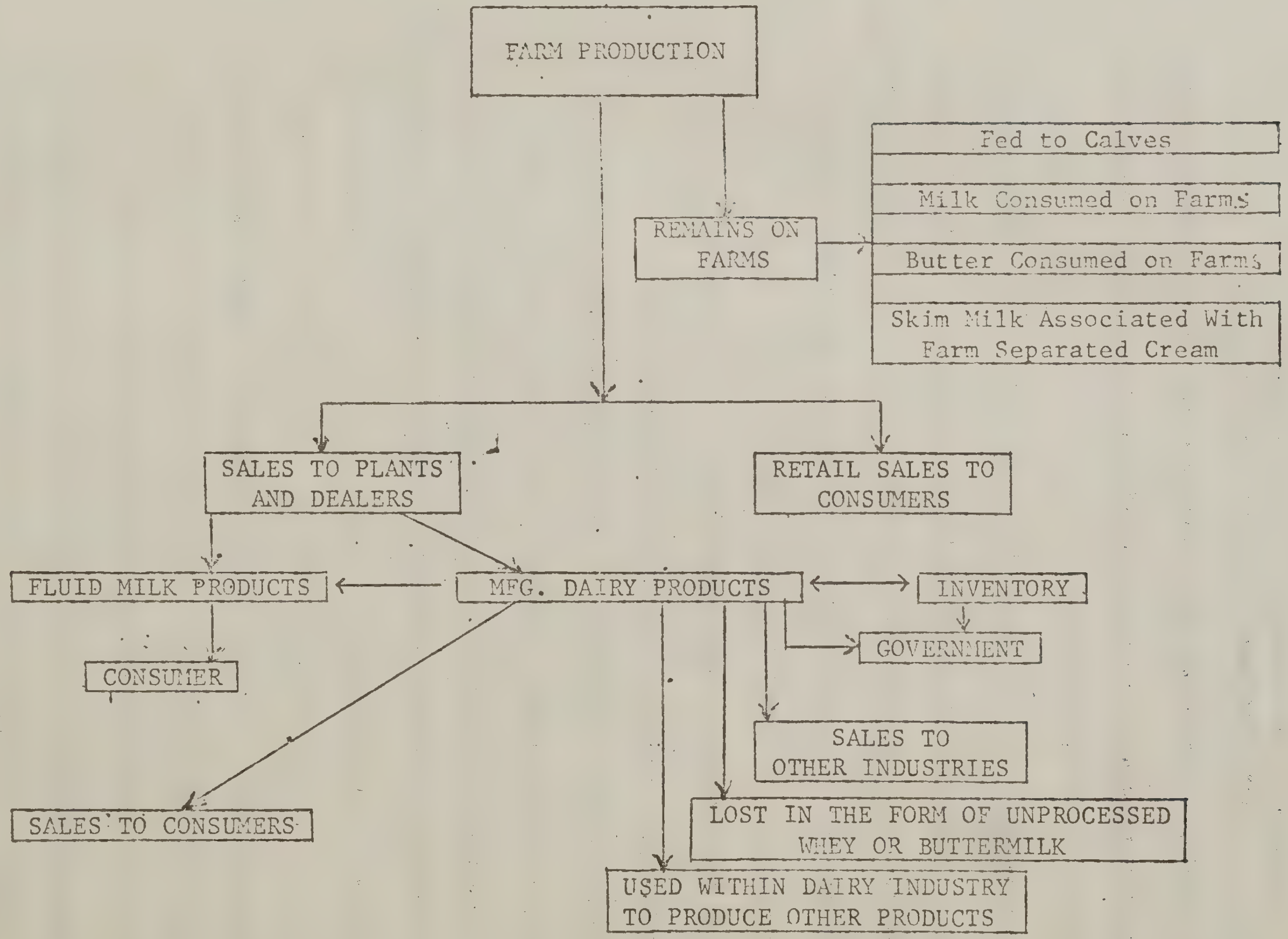


Figure 1

Butterfat and milk solids-not-fat to be accounted for are determined within two general stages in the system--fat and solids that remain on the farm, and fat and solids in fluid milk and cream that is marketed by farmers.

Entering the overall system is total milk production--product pounds, milk solids-not-fat pounds, and butterfat pounds. The portion of milk production remaining on farms is comprised of: (1) milk fed to calves, (2) milk consumed on farms, (3) milk consumed on farms as butter, and (4) skim milk associated with milk marketed by farmers as farm separated cream.

Fluid milk and cream marketed by farmers is total milk production less the sum of the above four items--milk production remaining on farms. It is comprised of milk and farm separated cream sales to plants and dealers and sales by farmers directly to consumers.

Cream marketed by farmers is reported on the basis of both butterfat and fluid milk equivalents. For reconciliation purposes the assumption is made that cream is marketed at 36 percent butterfat. It is also assumed that milk marketed by farmers enters the system at the same butterfat test as milk production. Given the pounds of milk and cream marketed by farmers, the pounds of butterfat marketed by farmers can be calculated (butterfat pounds associated with cream marketed is already given). Given the average butterfat test of producer milk, a formula was used to determine the solids-not-fat percentage of raw unstandardized producer milk. a/ The solids-not-fat percentage was then used to determine the pounds of solids-not-fat in raw producer milk marketed and to be accounted for in the system.

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a/ $N = 7.01 + 0.434(FP)$

where:

N = solids-not-fat percentage of raw producer milk.

FP = butterfat percentage of raw producer milk.

Source: Louis F. Herrmann, Elice D. Anderson, and Frank A. Bele, "Estimating the Solids-Not-Fat Content of Milk," USDA, AMS, MRR No. 65, May 1954.

Accounting for Fat and Solids-Not-Fat Marketed by Farmers

From the annual publication, "Production of Manufactured Dairy Products" the monthly and annual production of specified manufactured dairy products can be obtained. Since double accounting of milk components can be a problem in any milk component accounting system the following procedure was used in an attempt to avoid duplication.

(1) Butter and American cheese products were taken as reported.

(2) Creamed and partically creamed cottage cheese was assumed to be the final cottage cheese product consumed and the reported curd was used to produce creamed cottage cheese. It was assumed that 100 pounds of cottage cheese curd will yield 154 pounds of creamed cottage cheese. (This assumes the use of cream dressing of 12 percent butterfat.) To the extent that creamed and partially creamed cottage cheese production did not account for the curd that was produced the remaining curd was brought into the accounting system. The underlying assumptions were that the creamed or partially creamed figures were understated, that a cream dressing containing more than 12 percent butterfat was used, and also that some curd was consumed as curd (Appendix 2).

(3) Canned evaporated and condensed whole and skim milk were accounted for as reported. It was assumed that all bulk whole condensed milk products were used to produce other dairy products such as ice cream, and that 80 percent of the bulk condensed skim milk was used in this manner--20 percent going for food processing outside the dairy industry.

(4) Condensed buttermilk was accounted for and assumed to be used by industries other than dairy.

(5) All of the dry whole milk, dry skim milk and dry buttermilk was accounted for--both for human food and animal feed.

(6) So far as ice cream was concerned, only the mixes--ice cream, ice milk, milk sherbet, and mellorine-type--were accounted for. It was assumed that the frozen products were all made from these mixes.

(7) Adjustments were made to account for butterfat and solids-not-fat lost in the manufacturing process. Two primary areas for solids-not-fat loss are in cheese whey and buttermilk. It was assumed that for every pound of American cheese produced there was an associated 7.4 pounds of whey containing 0.4 percent butterfat and 6.6 percent solids-not-fat (Appendix 3). It was estimated that 90 percent of the butterfat in the whey was recovered in whey cream, manufactured into butter, and already included in butter production. Thus, only 10 percent of the fat associated with the whey was lost and hence was brought back into the system for accounting purposes. a/ However, all of the solids-not-fat was brought back into the system and reported figures on condensed and powdered whey were disregarded.

It was assumed that 3.4 pounds of whey were associated with every pound of cottage cheese curd produced. Since cottage cheese is made from skim milk, it was assumed the cottage cheese whey was fat-free but contained 7 percent solids-not-fat (Appendix 3). These solids were also brought back into the accounting system.

In creamery butter production, 1.27 pounds of buttermilk is associated with every pound of butter (Appendix 4). Some of this buttermilk is recovered in the form of condensed buttermilk and dried buttermilk. Any butterfat and solids-not-fat in buttermilk that was not accounted for by these two products was brought back into the accounting system.

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a/ The fat was brought back into the system for accounting purposes because it was not accounted for in any other dairy product.

Fluid milk product sales--other than farm consumption--are reported in the "Dairy Situation" on a product weight basis. a/ Also reported are the pounds of butterfat and nonfat milk solids associated with fluid milk product sales. The butterfat figures were used as reported, but a formula was used to estimate the milk solids associated with fluid milk products on an unfortified basis. b/ Solids-not-fat used in fortification of fluid milk products were not accounted for in the end use category because they were already accounted for at the point of manufacture.

An overall summation of butterfat and milk solids-not-fat in fluid milk products, manufactured products, and in whey and buttermilk lost in the production process gives the total pounds of butterfat and milk solids-not-fat accounted for. A comparison of these pounds with the butterfat and milk solids-not-fat marketed by farmers gives an indication of the accuracy of the accounting process (table 1).

Duplications:

Most of the duplications are taken care of by assuming that all of the bulk whole condensed milk and 80 percent of the bulk skim condensed milk was utilized within the dairy industry--primarily ice cream. This assumption is supported by the New York ice cream mix data which indicate that about 47 percent of the milk-solids-not-fat and 23 percent of the butterfat in ice cream mix is derived from condensed milk and condensed skim.

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a/ "Fluid milk product sales, various measures, U.S., selected years, 1950-71", Dairy Situation, May 1972, p. 19. Also, "Fluid milk product sales, various measures, U.S., 1950-65", Dairy Situation, July 1966, p. 18.

b/ The following formula was used for estimating the solids-not-fat content of standardized unfortified fluid milk products.

$$SNF = \left(\frac{N}{100-FP}\right)\left(100-FMP\right)$$

where SNF is percentage of solids-not-fat in standardized fluid milk product, N is percentage of solids-not-fat in producer milk, FP is percentage of fat in producer milk, and FMP is percentage of fat in fluid milk product.

The New York ice cream mix data indicate that about 18 percent of the milk solids-not-fat in ice cream mix is derived from dry skim milk, and about 9 percent from dry whole milk. No allowance was made for these forms of duplication. Only 2 percent of the butterfat in ice cream mix was derived from butter in 1971, but in 1969 it amounted to 7 percent. No allowance was made for this duplication.

Only the ice cream mix, ice milk mix, sherbet mix, and mellorine-type mix were used to compute fat and milk solids-not-fat used to produce ice cream. It was assumed that the mixes were used to produce the reported finished product pounds.

In cottage cheese production it was assumed that 100 pounds of curd yields 154 pounds of creamed or partially creamed cottage cheese. Reported cottage cheese curd was brought into the accounting system only to the extent that the reported creamed and partially creamed cottage cheese (given the 154-pound yield factor) did not account for the curd production (Appendix 2).

It was assumed that the increased volume of fluid milk products because of fortification with skim milk powder and condensed milk was already accounted for in the reported figures. And by considering milk powder and condensed milk as end uses, the problems of duplication associated with fortification of fluid milk products were minimized. Thus, if there is a problem associated with duplication, it undoubtedly centers around the ice cream and cottage cheese production processes. Undoubtedly some cottage cheese is produced from both fortified and reconstituted skim milk. However, the accounting procedure appears to be relatively accurate in spite of these shortcomings.

Table 1.--Reconciliation of Butterfat and Solids-Not-Fat for 1955-1971 Using the Procedure as Outlined for 1971 a/

(Difference between what can be accounted for and marketings by farmers)

| Year | Butterfat | | Solids-Not-Fat | |
|---|---|---|---|---|
| | (thous. lbs.) | (percent) | (thous. lbs.) | (percent) |
| 1955 | - 126,503 | - 3.06 | - 235,018 | - 2.86 |
| 1956 | - 104,279 | - 2.46 | - 261,354 | - 3.05 |
| 1957 | - 99,370 | - 2.33 | - 272,433 | - 3.10 |
| 1958 | - 98,650 | - 2.33 | - 280,217 | - 3.16 |
| 1959 | - 83,895 | - 2.00 | - 267,321 | - 2.96 |
| 1960 | - 85,423 | - 2.00 | - 282,471 | - 3.06 |
| 1961 | - 88,636 | - 2.02 | - 330,242 | - 3.45 |
| 1962 | - 68,450 | - 1.54 | - 259,533 | - 2.66 |
| 1963 | - 62,977 | - 1.44 | - 254,469 | - 2.60 |
| 1964 | - 56,961 | - 1.28 | - 236,684 | - 2.36 |
| 1965 | - 48,285 | - 1.10 | - 179,577 | - 1.81 |
| 1966 | - 56,107 | - 1.33 | - 149,725 | - 1.56 |
| 1967 | + 17,130 | + 0.40 | - 72,955 | - 0.76 |
| 1968 | + 18,246 | + 0.44 | - 7,075 | - 0.07 |
| 1969 | - 22,575 | - 0.55 | - 60,431 | - 0.64 |
| 1970 | - 12,211 | - 0.30 | - 16,243 | - 0.17 |
| 1971 | - 36,662 | - 0.87 | - 4,785 | - 0.05 |

a/ Butterfat and solids-not-fat associated with fluid milk products are based on the estimated fluid milk product sales (product weight basis) series originally developed in 1963 and data reported in the May issues of Dairy Situation. Since the calculations for this paper were made, a revised series was developed by Manchester which shows that sales of fluid milk items in terms of product weight in the United States may be somewhat below previous estimates. (See the May 1973 issue of Dairy Situation and ERS publication, "Sales of Fluid Milk Products", 1954-72, MRR No. 997, ERS, USDA, June 1973.)

Table 2.--Butterfat Test, Estimated Solids-Not-Fat Test of Unstandardized Producer Milk; and Estimated Solids-Not-Fat Test of Skim Milk Portion of Producer Milk, 1955-1971

| Year | Butterfat Test of Producer Milk (percent) | Solids-Not-Fat Test of Unstandardized Producer Milk a/ (percent) | Solids-Not-Fat Test of Skim Milk Portion of Producer Milk b/ (percent) |
|---|---|---|---|
| 1955 | 3.84 | 8.68 | 9.03 |
| 1956 | 3.82 | 8.67 | 9.01 |
| 1957 | 3.81 | 8.66 | 9.00 |
| 1958 | 3.78 | 8.65 | 8.99 |
| 1959 | 3.76 | 8.65 | 8.99 |
| 1960 | 3.76 | 8.65 | 8.99 |
| 1961 | 3.75 | 8.64 | 8.98 |
| 1962 | 3.74 | 8.63 | 8.96 |
| 1963 | 3.71 | 8.62 | 8.95 |
| 1964 | 3.70 | 8.62 | 8.95 |
| 1965 | 3.70 | 8.62 | 8.95 |
| 1966 | 3.69 | 8.61 | 8.94 |
| 1967 | 3.69 | 8.61 | 8.94 |
| 1968 | 3.67 | 8.60 | 8.93 |
| 1969 | 3.67 | 8.60 | 8.93 |
| 1970 | 3.66 | 8.60 | 8.93 |
| 1971 | 3.67 | 8.60 | 8.93 |

a/ Derived from the formula $N=7.01 + 0.434(FP)$
where N is percentage of solids-not-fat and FP is percentage of fat in producer milk.
(Source: Louis F. Herrmann, Elsie D. Anderson, and Frank A. Bele, "Estimating the Solids-Not-Fat Content of Milk", USDA, AMS, MRR No. 65, May 1954.)

b/ Derived from the formula $NS = \frac{N}{100-FP}$
where NS is percentage of solids-not-fat in skim milk portion of producer milk, and N and FP are as defined in a/ above.

1971

Butterfat and Solids-Not-Fat to be Accounted For

| | Thousand Pounds |
|---|---|
| Total Milk Production a/ | 118,640,000 |
| Less: | |
| Milk fed to calves | 1,666,000 |
| Milk consumed on farms | 2,177,000 |
| Milk equivalent of cream marketed by farmers | 997,000 b/ |
| Total milk marketed by farmers | 113,800,000 |
| 36% cream marketed by farmers: | |
| Butterfat in cream marketed by farmers of 36,000 x 2.778 | 100,008 b/ |
| Milk marketed by farmers: | |
| As whole milk (sold to plants and dealers) | 112,189,000 |
| Sold directly to consumers | 1,611,000 |
| | 113,800,000 |
| Butterfat in: | |
| 36% cream marketed by farmers (100,008 x .36) | 36,000 |
| Whole milk (113,800 x .0367) | 4,176,460 |
| Total butterfat to account for | 4,212,460 |
| Solids-not-fat in: | |
| 36% cream marketed by farmers (100,008 x .0572) | 5,720 |
| Whole milk (113,800 x .0860) | 9,786,800 |
| Total solids-not-fat to account for | 9,792,520 |

a/ The data source is "Milk: Production, Disposition, and Income" published annually in April. These data are revised after agricultural census years. Revised estimates 1955-59 are in Statistical Bulletin No. 282, April 1961. Revised estimates 1960-64 are in Statistical Bulletin No. 398, April 1967.

b/ Assumed the 997,000,000 pounds of whole milk was actually marketed as 36% cream and that 896,992,000 pounds of skim milk remained on farms--i.e. did not enter the marketing system.

## 1971

### Butterfat and Solids-Not-Fat Accounted For

| Product | B.F. (%) | SNF (%) | Product (thous.lbs.) | Butterfat (thous.lbs.) | Solids-Not-Fat (thous.lbs.) |
|---|---|---|---|---|---|
| Butter | 80.3 | 1.0 | 1,143,557 | 918,230 | 11,435 |
| Cheese a/ | | | 2,372,504 | 723,918 | 692,588 |
| Dry Whole Milk | 26.5 | 71.0 | 72,156 | 19,106 | 51,191 |
| Nonfat Dry | 0.8 | 96.0 | 1,429,044 | 11,431 | 1,371,740 |
| Evap. & Condensed: | | | | | |
| Whole canned | 7.9 | 18.0 | 1,268,086 | 100,172 | 228,240 |
| Skim canned | 0.2 | 29.8 | 22,684 | 45 | 6,760 |
| 20 of bulk condensed skim milk | 0.2 | 29.8 | 203,270 | 407 | 60,574 |
| Creamed Cottage Ch. | 4.2 | 17.5 | 1,003,422 | 42,143 | 175,595 |
| Low-fat Cottage Ch. | 2.0 | 19.0 | 81,246 | 1,625 | 15,437 |
| Cottage Cheese Curd b/ | 0.3 | 20.7 | 37,628 | 113 | 7,789 |
| Dry Buttermilk | 5.3 | 91.9 | 51,727 | 2,742 | 47,537 |
| Condensed Buttermilk | 1.5 | 26.4 | 10,174 | 153 | 2,686 |
| Frozen Dairy Products g/ | | | | 445,659 | 613,412 |
| Fluid Milk Products c/ | 3.21 | 8.64 | 59,200,000 | 1,900,000 | 5,114,880 |
| Cheddar Cheese Whey d/ | | | | 7,023 e/ | 1,158,729 |
| Cottage Cheese Whey d/ | | | | 0 | 176,583 |
| Dry Buttermilk Lost f/ | 5.3 | 91.9 | | 3,031 | 52,559 |
| Total | | | | 4,175,798 | 9,787,735 |

a/ See Appendix 1.

b/ Cottage cheese curd not accounted for in creamed or partially creamed cottage cheese--Appendix 2.

c/ Data from Dairy Situation.

d/ Appendix 3.

e/ Ten percent of whey fat lost (assume 90% is recovered in whey butter)--Appendix 3.

f/ Appendix 4.

g/ Appendix 5.

## Appendix 1

### Cheese, 1971

| Product | % Fat | % SNF | Product (thous. lbs.) | Butterfat (thous. lbs.) | Solids-Not-Fat (thous. lbs.) |
|---|---|---|---|---|---|
| American | 32 | 30 | 1,510,400 | 483,328 | 453,120 |
| Italian | 24.8 | 30.2 | 453,021 | 112,349 | 136,812 |
| Swiss | 28 | 32 | 153,843 | 43,076 | 49,230 |
| Cream | 37 | 12 | 125,332 | 46,373 | 15,040 |
| Neufchatel | 26 | 17 | 4,497 | 1,169 | 764 |
| All Other Types | 30 | 30 | 125,407 | 37,622 | 37,622 |
| Total | | | 2,372,500 | 723,917 | 692,588 |
| | | | | 30.51% | 29.19% |

## Appendix 2

### Cottage Cheese, 1971

| | Thousand Pounds |
|---|---|
| Creamed cottage cheese | 1,003,422 |
| Partially creamed cottage cheese | 81,246 |
| Total | 1,084,668 |

| | |
|---|---|
| Cottage cheese curd reported produced | 741,944 |
| Less: | |
| Cottage cheese curd associated with creamed and partially creamed cottage cheese: | |
| $\frac{1,084,668}{1.54\ \underline{a}/} =$ | 704,316 |
| Cottage cheese curd not accounted for | 37,628 |

a/ Assumes a curd yield of 15 percent and a cream dressing of 12 percent butterfat.

## Appendix 3

Whey Associated with American Cheese Production, 1971

| | |
|---:|---|
| 2,372,504,000 | lbs. |
| 7.4 | lbs. of whey/pound of cheese |
| 17,556,529,600 | lbs. of whey |

0.4% Fat = 70,226,120 a/ x 10% = 7,022,612 lbs.
6.6% SNF = 1,158,730,980 lbs.

a/ Assume 90% of this is recovered and accounted for in whey butter.

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Whey Associated with Cottage Cheese Production, 1971

| | |
|---:|---|
| 741,944,000 | lbs. curd |
| 3.4 | lbs. of whey/pound of curd |
| 2,522,609,000 | lbs. of whey |

7.0% solids-not-fat

| | |
|---:|---|
| 2,522,609,000 | |
| .07 | |
| 176,583,000 | lbs. solids-not-fat |

Assume curd is made from skim milk and no fat in the whey.

## Appendix 4

Buttermilk Associated with Creamery Butter Production, 1971

| | |
|---|---|
| 1,143,000 | thousand pounds of butter |
| 1.27 | pounds of buttermilk per pound of butter |
| 1,452,244 | thousand pounds of buttermilk |

| | |
|---|---|
| 1,452,244 | thousand pounds of buttermilk |
| 7.5 | pounds of pwd. buttermilk per cwt. of buttermilk |
| 108,918 | thousand pounds of pwd. buttermilk potential |

| | |
|---|---|
| 108,918 | thousand pounds of pwd. buttermilk potential |
| - 51,727 | thousand pounds of pwd. buttermilk equiv. produced |
| 57,191 | thousand pounds of pwd. buttermilk equiv. not salvaged |

Butterfat in pwd. buttermilk equiv. not salvaged:

57,191 x .053 = 3,031 thousand pounds

Solids-not-fat in pwd. buttermilk equivalent not salvaged:

57,191 x .919 = 52,559 thousand pounds

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## Appendix 5 -- Frozen Dairy Products, 1971

| Product | Ice Cream mix (thous. gallons) | Pounds per Gallon | Ice Cream mix (thous. lbs.) |
|---|---|---|---|
| Ice Cream Mix | 395,441 | 9.0 | 3,558,969 |
| Ice Milk Mix | 175,540 | 9.0 | 1,579,860 |
| Milk Sherbet Mix | 31,181 | 10.0 | 311,810 |
| Mellorine-Type Mix. | 26,022 | 9.0 | 234,198 |

| Product | Fat (percent) | SNF (percent) | Butterfat (thous. lbs.) | Milk Solids-Not-F (thous. lbs.) |
|---|---|---|---|---|
| Ice Cream Mix | 11.0 | 10.5 | 391,487 | 373,692 |
| Ice Milk Mix | 3.0 | 13.0 | 47,936 | 207,722 |
| Milk Sherbet Mix | 2.0 | 2.0 | 6,236 | 6,236 |
| Mellorine-Type Mix | 0.0 | 11.0 | | 25,762 |
| Total | | | 445,659 | 613,412 |

# Some Additional Variables for Milk Supply Models? 1/

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## OVERVIEW

Of the six subsystems listed by Hallberg, my current interests are strictly in the production subsystem. Most macro-level milk supply models include some combination of most of the following variables:

1. Product price (milk and cull livestock)
2. Input prices
3. Prices of competing products
4. Numbers of cows and potential replacements
5. Time and/or some measure of technological change

Results of the analyses of producer panel data have shown that changes in milk production on individual farms are related to a somewhat different group of variables. My objective is to examine these micro-level supply response studies to see if they might help us improve our macro-level supply response equations.

Tix and Sundquist (3) 2/ analyzed changes in milk production on farms in the Minnesota Producer Panel. They found that age of operator was the most important variable explaining changes in milk production. Sizes of competing enterprises and prices of the products of competing enterprises sometimes had significant coefficients. The cropland/labor ratio and the number of sons at home also had significant coefficients in some equations.

1/ Journal series number 4513, Pennsylvania Agricultural Experiment Station.
2/ Underscored items in parenthesis refer to items in Literature Cited.

Conneman (2) investigated changes in milk production between 1960 and 1964 on 1,658 farms included in the Producer Panel made up of farmers in the New York milk shed. The independent variables included in his analysis were:[3/]

1. Crop acres operated in 1960 (owned and rented).
2. Milk sold per cow in the 1960-61 production year.
3. Crop acres per cow in the 1960 season.
4. Net price received for milk in 1960-61.
5. Barn capacity in June 1960.
6. Change in net price between 1960-61 and 1963-64.
7. Size of labor force in June 1960.
8. Age of operator in June 1960.
9. Index of level of mechanization.
10. Method of delivering milk (bulk or can).
11. Number of cows in June 1960.

He found that age of operator had a negative coefficient and was a very important factor influencing change in output regardless of whether the dependent variable was absolute or percentage change in production. Unlike the Minnesota study, the size variable was also important regardless of whether size was measured in terms of barn capacity, crop acres, man equivalent, or number of cows. The sign of the regression coefficient was generally positive even when percentage change in milk production was

3/ From conversations with Conneman I know that he included other variables in preliminary analyses, but unfortunately he did not report them in his thesis.

the dependent variable. The price variable, net price and change in net price, generally had positive coefficients. Of the two, net price was the more important.

Conneman found equally interesting relationships that were not reflected in his regression equations. He found very large differences in the elasticity of the response functions between areas. Examination of these differences leads one quickly to the hypothesis that changes in production are strongly influenced by the presence of off-farm and on-farm alternatives to dairying. Farms in the North Country, an area north and west of the Adirondacks, have almost no alternative to dairying either in the form of other enterprises on their farms or off-farm jobs available within driving distance of their homes. This area had a very inelastic supply response. The Central Pennsylvania area had a far more elastic response. Most farmers in this area have both farm alternatives to dairying and opportunities for off-farm jobs.

Using tabular analysis, Conneman found that presence of a son of high school age or older was positively related to changes in milk production. He also found interactions between herd size and age, and between a hill-valley classification and age in one area. Unfortunately, he did not include these relations in his regression equations.

Despite the significance of several variables in the regression equations, only a small part of the variation in milk production was explained. Most of the $R^2$ were less than .10. Much higher $R^2$'s were obtained when entry and exit farms were analyzed separately than when all farms were analyzed together. This indicates that decisions to enter or leave the

dairy business are based on different factors, or different weights in the same factors, than decisions to moderately expand or reduce the herd. This hypothesis is supported by the Minnesota study which showed different results when farms with major changes in production were analyzed separately.

Of the 1658 farms in Conneman's producer panel, 409 were located in Pennsylvania. Benson (1) used the data from these 409 farms for further study. He supplemented this with secondary data selected to reflect both on-farm and off-farm alternatives to dairying. Preliminary investigation confirmed the hypothesis that the parameters of exit farms, entrant farms, and continuous producers were significantly different. Therefore, the three were analyzed separately. Five types of variables were included in the analysis. These were:[4/]

a. Variables reflecting the personal characteristics of the farm operator
   1. Age of operator in June 1960.
   2. Educational level attained by the operator.
   3. Milk sales per cow in the 1960-61 production year (an index of managerial ability).

b. Price variables
   1. Net price of milk (1960-61).
   2. Change in net price from the 1960-61 production year to the 1963-64 production year.

c. Variables describing on-farm alternatives to dairying.
   1. Percentage of total county farm sales resulting from dairy production.

4/ Other variables in each category were dropped after preliminary screening.

d. Variables describing off-farm alternatives to dairying.

1. Total employment in the local labor market area.

2. Unemployment rate in the local labor market area.

e. Variables describing the farm's resources.

1. Number of cows in June 1960.

2. Percent of barn capacity utilized in June 1960.

As further expansion of Conneman's work, curvilinear functions and interaction terms involving age, number of cows and production per cow were included in the analysis.

About 40 percent of the variation was explained when absolute change in milk production was the dependent variable. Significant independent variables were milk price; change in milk price; and curvilinear and interaction terms involving age of operator, number of cows and production per cow. "Percent of county farm sales from dairying" and "operator's off-farm income" were significant in the linear models but not in the models involving more complex variables. Variables reflecting off-farm alternatives to dairying were not significant. However, we were investigating farms in a relatively uniform area with respect to off-farm alternatives.

The interaction terms explained most of the variation in the dependent variable. The interactions were quite complex. If two of the three variables--age, cow numbers, and production per cow--were varied while all other variables remained constant, the resulting surface was very convoluted. For example, the effects of production per cow on change in production was quite different for farms of different sizes or for farmers of different ages.

The effects of proportional change in production were also investigated. Variables which survived an initial screening in this analysis were:

1. Age of operator.
2. Educational level attained by the operator.
3. Net price of milk (1960-61).
4. Percentage of total county farm sales resulting from dairy production.
5. Total employment in the local labor market area.
6. Unemployment rate in the local labor market area.
7. Percent of barn capacity utilized in June 1960.
8. The ratio of crop acres to cow numbers.
9. Days worked off the farm by the farm operator.
10. Annual income earned by other family members.
11. Acres of cropland operated.
12. Method of delivering milk (bulk or can).

The results were similar to those obtained when absolute change in milk production was the dependent variable with one important exception. The effects of size appeared to have been removed by the transformation of the dependent variable. No linear or curvilinear functions of herd size were identified which were significant at the 5% level. The only significant interaction terms involved size and production per cow. These results suggest that the effects of size were proportionate.

There were too few entrants in the panel for regression analysis. However, the 81 farms who ceased production during the period of the panel

were analyzed. Discriminant analysis was used to find factors which distinguished between those farmers who remained in dairying and those who ceased production.

A significant relationship involving age showed that the youngest and oldest operators were most likely to quit producing milk. Crop acres per cow were inversely related to the likelihood of stopping milk production. The number of days worked off-the-farm by the operator was positively related to the likelihood of leaving farming. This suggests that part-time work may be a stepping stone to full-time non-farm employment. The level of off-farm income earned by other family members was significant and the relationship suggests that higher income was associated with a reduced likelihood of leaving dairy farming. The education received by the operator was not a significant variable.

The availability of on-farm alternatives was measured by the percentage of county farm receipts from dairying. The relationship of this variable to the dependent variable was not statistically significant. Two measures of off-farm alternatives were included in the analysis--the total number of employed persons in the local labor market area and the unemployment rate in the same area. A greater likelihood of discontinuing milk production was observed in areas with greater employment. The unemployment rate was not a significant variable.

Crop acreage was taken as a measure of the size of the farm business and showed that farms with smaller acreages were more likely to stop producing milk than were larger farms. No significant relationships were identified for two variables selected to measure the level of technology on the farm and the efficiency of resource use.

Net price received in 1960 and change in net price were not significant variables. No interaction effects were identified.

Although age, size, and off-farm employment opportunities helped to explain why farmers quit the dairy business, the explanatory power of the model was low. However, the more important result was to demonstrate that the reasons farmers exit from dairying were somewhat different than those which cause continuous producers to change their level of production.

## Implication for Macro-Supply Studies

These three studies show some variables that explain part of the changes in milk production on individual farms. For each variable two questions must be answered: (1) Does the variable have aggregate effects as well as effects on the individual farm? and (2) Can the date necessary to incorporate the variable be obtained?

Of the variables identified in the producer panel studies, the price variables and production per cow are included in our proposed model. Let us turn our attention to the age and size variables. Probably we could obtain data that would reflect change in average age of dairy farmers and in the distribution of sizes of firms. These might be picked up from statistics for different milk markets or from SRS data from major dairy states. However, this type of data might hide more than it reveals. Remember that Benson's model found that the most important terms, in terms of $R^2$, were interactions among age, size and production per cow. This would indicate that separate estimates should be made for different age, size, and production combinations. I doubt if data in this detail are

available for very many important producing regions. Even if we had such data, we might find that the aggregate effect of changes in the individual categories is of minor importance. However, I do think it might be worthwhile to see if we can improve estimates by incorporating variables reflecting changes in the age of distribution of farmers or in the size distribution of farms.

On-farm and off-farm alternatives to dairying were also found to have some importance in explaining changes in production on individual farms and even more importance in identifying farms who may exit from the dairy business. However, I am not sure how important these variables would be when we are estimating response on a regional basis. For example, farms in the North Country area in New York have almost no off-farm alternatives. Yet, they are in the Northeast region where most variables would indicate many off-farm alternatives. However, we might improve our models by including such variables as change in employment in the manufacturing and service industries or even changes in the unemployment rate. As to on-farm alternatives, the proposed inclusion of the prices of competing agricultural products may capture a part of their effect on milk production.

Results of these studies show farmers cease production for a somewhat different set of reasons than those which cause other farmers to change their level of production. It might be worthwhile to investigate the possibility that the inclusion of an equation reflecting changes in numbers of farms would improve the model.

# LITERATURE CITED

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# Aggregate Supply Model for the Dairy Industry Based on Biological as well as Economic Considerations

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Almost without exception, previous efforts at aggregate supply analysis in the dairy industry have concentrated on the estimation of models in which aggregate milk production is the dependent variable and milk price (or its lag distribution) together with other hypothesized factors are the independent variables. 1/ This procedure often leads to problems, the most frequent of which (at least in analysis using recent data) is "incorrect" signs on the coefficients.

It should be recognized that an aggregate supply function of this form is a "reduced form" equation. As such it masks several important underlying structural relations. When these structural relations are ignored, not only do we lose information but there is a strong possibility that misspecification of the supply function can creep in to produce biased estimates.

In this paper I propose a model which is constructed on the basis of biological as well as economic considerations. The model is designed to yield information on dairy cow numbers, dairy heifer numbers, dairy-beef production as well as output

1/ J. G. Elterich and E. M. Johnson, A Recursive Milk Production Model. Delaware Agr. Exp. Sta. Bul. 381, June 1970.

per cow. This type of model has, unfortunately, received only limited attention to date. Elterich and Johnson 1/ have published a report in which milk supply is attacked via this approach. While I would quarrel with some of their formulations, their work is very promising and should be encouraged. 2/ In addition, their work goes beyond the model outlined here in that it includes capital and labor use equations. (Something in which we should be very much interested at some point in the future.)

## STRUCTURAL MODEL

The structural model specified is based on a simple accounting equation, on biological considerations outlined by Frick and Henry, 3/ and on hypothesized behavioral processes. For some of the parameters of this structure, estimates are shown in parentheses below the respective parameters. These estimates are taken from Frick and Henry and assume (presumably) better-than-average management. They are included here only to give the reader an idea of the likely magnitude of the parameters under consideration.

This model is intended to be applicable to regions. Hence, in the equations described below, subscript i refers to region i. Subscript t refers to year t.

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2/ These same authors have extended their work for the entire Northeast. These results have not been published to date.

3/ G. E. Frick and W. F. Henry. Production Efficiency on New England Dairy Farms. New Hampshire Exp. Sta. Bul. 430. 1956.

Cows on hand at beginning of year

The basic accounting identity by which to determine the stock variable, number of cows on hand at the start of year t, is:

(1.1) $COWS_{it} = COWS_{it-1} + REPLACE_{it-1} - CULLS_{it-1} - DEATHS_{it-1}$

Here COWS (a stock variable), CULLS (a flow variable), and DEATHS (a flow variable) refer to two year and older dairy cows. CULLS measures the number of cows culled by the end of the year regardless of cause (and presumed sold for beef) and DEATHS measures the number of cows that died by the end of the year. REPLACE refers to the newly freshening (two-year-old) heifers added to the herd during the year. I assume here that if cows older than two years are purchased by dairy farmers, they are purchased from within the region. REPLACE, however, may include heifers purchased from regions other than region i.

Deaths

(1.2) $DEATHS_{it} = a_{21} COWS_{it} + a_{22} REPLACE_{it}$

$a_{21}$ = death rate for dairy cows two years and older on hand at beginning of year.

$a_{22}$ = death rate for newly freshening heifers.

The parameters $a_{21}$ and $a_{22}$ will depend on the level of management, but for any one region should be fairly constant over time.

Culling rate for cows

This is a behavioral relation that should reflect how farmers make decisions with respect to culling cows out of their herd. I hypothesize they make these decisions on the basis of the income they expect to make from dairying relative to that they can make in some reasonable alternative. This is likely to be judged on the basis of recent history. Also, I would expect the culling rate to be a function of the proportion of newly freshening heifers in the herd. Thus I propose the relation:

$$(1.3)\quad (CULLS_{it} / Z_{it}) = a_{30} + a_{31} PC_{it} + a_{32} PF_{it} + a_{33} PN_{it} + a_{34} U_{it} + a_{35} (REPLACE_{it}/COWS_{it})$$

where

$Z_{it}$ = $COWS_{it}$ + $REPLACE_{it}$

$PC_{it}$ = price of canners and cutters in year t relative to price of milk in year t

$PF_{it}$ = (weighted) average over the past x years of the ratio of profitability from dairying to profitability from other (relevant) farming enterprises.

$PN_{it}$ = (weighted) average over the past y years of the ratio of profitability from dairying to income attainable from (relevant) nonfarm opportunities.

$U_{it}$ = an indicator of pressure for urban expansion.

Calves produced during year

$$(1.4.1)\quad CALVINGS_{it} = \underset{(0.90)}{a_{41}}(COWS_{it} + REPLACE_{it})$$

$$(1.4.2)\quad SINGLES_{it} = \underset{(0.97)}{b_{41}}\ \underset{(0.95)}{b_{42}}\ CALVINGS_{it}$$

$$(1.4.3)\quad TWINS_{it} = 2\ \underset{(0.03)}{C_{41}}\ \underset{(0.80)}{C_{42}}\ CALVINGS_{it}$$

where

$a_{41}$ = calving rate

$b_{41}$ = single birth rate

$b_{42}$ = at birth survival rate for singles

$C_{41}$ = twin birth rate

$C_{42}$ = at birth survival rate for twins

Heifer calves produced during year

$$(1.5)\quad HEIFERS_{it+1} = \underset{(0.488)}{a_{51}}\ SINGLES_{it} + \underset{(0.270)}{a_{52}}\ TWINS_{it}$$

$a_{51}$ = proportion of singles which are heifers

$a_{52}$ = " " twins " " "

Herd replacements during (t + 2)

Let us define the following parameters:

$CAFCULL_i$ = proportion of heifer calves culled during first six months (and presumably sold for veal)

$a_{61}$ = proportion of heifer calves that survive for six months

$a_{62}$ = proportion of heifer calves 6-months old that survive for next 12 months

$a_{63}$ = proportion of heifer calves 18-months old that are fertile.

$a_{64}$ = proportion of 18 month old heifer calves that survive next 6 months.

Then regardless of whether or not heifer calf births are equally distributed over the year:

$$(1.6.1)\quad HEIFERS_{it+2} = \underset{(.99)}{a_{64}}\ \underset{(.92)}{a_{63}}\ \underset{(.98)}{a_{62}}\ \underset{(.90)}{a_{61}}\ CAFCULL_{it}\ HEIFERS_{it}.$$

Finally

$$(1.6.2)\quad REPLACE_{it+2} = HEIFERS_{it+2} + IMPORTS_{it+2}$$

Heifer calf culling rate

As in the case of the cow culling rate, CAFCULL should be a function of farmers decisions with respect to the expected attractiveness of dairying. Hence I propose:

(1.7) $CAFCULL_{it} = a_{70} + a_{71}\ PV_{it} + a_{72}\ PF_{it} + a_{73}\ PN_{it} + a_{74}\ U_{it}$

where

$PV_{it}$ = price of vealers relative to price of milk.

Veal calves marketed during year t

(1.8) $VEAL_{it} = \underset{(0.512)}{(1-a_{51})} SINGLES_{it} + \underset{(0.730)}{(1-a_{52})} TWINS_{it} + CAFCULL_{it}\ HEIFERS_{it}$

Milk output per cow

We know that several factors are responsible for variations in milk output per cow. The amount and quality of feed fed is important and should reflect most of the peculiarities brought about by nature (e.g., Agnes ). Also new technological developments in feeding and in genetics are likely to be important. Finally, I would expect output per cow for an aggregate of cows to be a function of the number of newly freshening heifers in the herd. Thus, I propose:

(1.9) $OUTPUT_{it} = a_{90} + a_{91}\ G_{it} + a_{92}\ F_{it} + a_{93}\ T + a_{94}(REPLACE_{it}/COWS_{it})$

where

OUTPUT = milk output per cow
G = quantity of grain fed
F = quantity and quality of roughage fed
T = technology indicator

## MODEL ESTIMATION

Since data in sufficient detail to estimate all parameters of this model are unavailable, substantial simplification is needed to formulate an estimable model. In effecting this simplification, we sacrifice some detail but retain the basic model structure.

Data are available from SRS to estimate COWS and REPLACE. For example, we can define:

$COWS_t$ = milk cows two-years old and older kept for milk, January 1.

$REPLACE_t$ = Heifers one-two years old kept for milk, January 1.

Data with which to observe DEATHS and CULLS directly are unavailable, but these two variables could be estimated collectively as a residual from equation (1.1). If this were done, equation (1.3) would have to be interpreted accordingly. Alternatively one may wish to assume a value for the parameters, $a_{21}$ and $a_{22}$, in equation (1.2) and estimate DEATHS directly. I will assume hereafter that CULLS includes DEATHS.

CALVINGS, SINGLES, TWINS cannot be observed directly. Hence equation (1.5) must be replaced with the reduced form equation:

$$(2.2) \quad HEIFERS_{it} = d_{21} \left(COWS_{it-1} + REPLACE_{it-1}\right)$$

Similarly since CAFCULL cannot be observed directly, we have

$$(2.3)\ HEIFERS_{it+2} = (d_{30} + d_{31}\ PV_{it} + d_{32}\ PF_{it} + d_{33}\ PN_{it} + d_{34}\ U_{it})HEIFERS_{it}$$

For equations (2.2) and (2.3) we can observe $HEIFERS_t$ directly as the SRS series, "heifer calves kept for milk, January 1".

Finally IMPORTS is a nonobservable variable. I assume here that the propensity to import heifers is relatively constant and is adequately reflected in equation (2.3).

We now have the estimable model:

$$(2.1)\ COWS_{it} = COWS_{it-1} + REPLACE_{it-1} - CULLS_{it-1}$$

$$(2.2)\ HEIFERS_{it} = d_{21}\ (COWS_{it-1} + REPLACE_{it-1})$$

$$(2.3)\ REPLACE_{it+2} = (d_{30} + d_{31}\ PV_{it} + d_{32} PF_{it} + d_{33}\ PN_{it} + d_{34} U_{it})HEIFERS_{it}$$

$$(2.4)\ (CULLS_{it}/Z_{it}) = a_{30} + a_{31}\ PC_{it} + a_{32}\ PF_{it} + a_{33}\ PN_{it}\ a_{34}\ U_{it} + a_{35}\ H_{it}$$

$$(2.5)\ OUTPUT_{it} = a_{90} + a_{91}\ F_{it} + a_{92}\ G_{it} + a_{93}\ T_{it} + a_{94}\ H_{it}$$

where

$$H_{it} = REPLACE_{it}/COWS_{it}$$

Notice that this model is completely recursive due to the life-cycle nature of its basic underpinnings. It will generate

cow numbers on the basis of both biological and economic (behavioral) considerations. In model (2.1) - (2.4) there is no equation with which to generate veal calf numbers. Reasonable assumptions about the parameters in the structural model may be sufficient to produce reliable estimates here.

### Some Preliminary Empirical Results

I have estimated the model (2.1) - (2.5) using annual data for the entire United States for the period 1955-1970. My intent was to illustrate the possibilities here rather than to provide final empirical content to the model.

Each equation of this model was estimated by O.L.S. Unfortunately data in the form I would have desired was not readily available so I was forced to eliminate some interesting variables. Also, of course, results based on so few observations leaves something to be desired. For the following estimated equations, t-values are given in parenthesis below each parameter estimate:

$$(2.5)\ \text{HEIFERS}_t = -3305.59 + \underset{(7.45)}{0.2113}\ Z_t + \underset{(3.77)}{13259.75}\ H_t$$

$$R^2 = 0.935$$

$$(2.3')\ \text{REPLACE}_t = 786.60 + (\underset{(6.35)}{0.8640} - \underset{(0.73)}{0.0131}\ PV_{t-3} +$$

$$\underset{(1.39}{0.0392}\ PF_{t-3} - \underset{(2.07)}{0.0002}\ PN_{t-3})\ \text{HEIFERS}_{t-2}$$

$$R^2 = 0.984$$

$$(2.4') \quad CULLS_t/Z_t = 0.6232 + 0.0064\, PC_{t-1} + 0.0097\, PF_{t-1} +$$

$$\qquad (0.32) \qquad (0.73)$$

$$0.0001\, PN_{t-1} - 2.2708\, H_t$$

$$(2.67) \qquad (2.04)$$

$$R^2 = 0.813$$

$$(2.5') \quad OUTPUT_t/COW_t = 7.9382 + 1.5718\, H_t + 0.2405\, TIME$$

$$(0.76) \qquad (49.58)$$

$$R^2 = 0.997$$

$Z_t$ = $COWS_t + REPLACE_t$

$H_t$ = $REPLACE_t/COWS_t$

$PV_t$ = Price veal calves ÷ price of all milk wholesale

$PF_t$ = Price beef ÷ price of all milk wholesale

$PN_t$ = Construction earnings ÷ price of all milk wholesale

Construction earnings was used here as a proxy for off-farm attractions, price of all milk wholesale as a proxy for "net income from dairying", and price of beef as a proxy for "income possibilities from an on-farm alternative to dairying".

# Projecting Selected Size Characteristics of The Production Sector of the Dairy Industry

by

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## INTRODUCTION

### The Task

Commensurate with generating total U.S. milk production projections using regression models was the need to allocate production estimates among nine regions and among farms of different herd size within each region. Any approach to accomplishing this task necessarily includes the basic structural variables of farm numbers, cow numbers, and output per cow. The general approach employed for study was to generate independent sets of regional structural estimates and then aggregate to total U.S. milk production estimates.

### Data

An early consensus decision of the task force was to gear all projection estimates of milk production to readily available published Statistical Reporting Service dairy statistics. Total milk production and sales, milk cow numbers, and production per cow data are available from SRS annually (and monthly) by State. These statistics at the regional level were computed using SRS data for the respective individual States.

Agricultural census information for selected years was used: (1) to check against SRS data where possible, (2) to establish benchmark production per cow data for selected herd size categories or strata (1964 census), and (3) to project farm and cow numbers by herd size. Some gaps in the total information system were filled by using individual State and U.S.D.A. research reports. Other gaps were filled subjectively by using the experience and judgment of the researcher assigned this task. A summary of the nature of most of the data base used by source is shown in table 1 below.

Table 1--Type and source of information used for the special ERS dairy study for ASCS, 1972

| Type of Information | Source of Information | | | |
|---|---|---|---|---|
| | Agr. Census | | | SRS |
| Total milk production | NA | NA | NA | Annual, 1959-1972 |
| Total milk sold | NA | 1964 | NA | " , 1959-1972 |
| By herd size stratum | NA | 1964 | NA | NA |
| Total milk cow numbers: | | | | |
| On all farms | 1969 | 1964 | 1959 | Annual, 1959-1972 |
| By herd size stratum | NA | 1964 | NA | NA |
| On Economic Class I-V farms only | 1969 | 1964 | 1959 | NA |
| By herd size stratum | 1969 | NA | NA | |
| Farms with milk cows: | | | | |
| All farms | 1969 | 1964 | 1959 | NA |
| By herd size stratum | NA | 1964 | 1959 | NA |
| Economic Class I-V farms only | 1969 | 1964 | 1959 | NA |
| By herd size stratum | 1969 | 1964 | 1959 | NA |
| Milk production per cow: | | | | |
| All farms | NA | NA | NA | Annual, 1959-1972 |
| Milk sold per cow: | | | | |
| All farms | NA | 1964 | NA | Annual, 1959-1972 |
| By herd size stratum | NA | 1964 | NA | NA |

NA = not available.

## Procedure

The first objective was to generate a set of up-to-date benchmark information integrating census and SRS statistics to serve as a launching pad for projecting the dairy production sector structure anywhere from 1 to 5 years hence. Early investigation led quickly to the conclusion that using Markov chains as the basis for projecting census farm numbers can lead to grossly inaccurate distributions. A few of the individual matrix probabilities for each region were salvaged intact; most had to be modified. In all cases, however, Markov chains were used as an initial approximating technique. A fairly detailed stepwise outline of the procedure which was developed and applied to each of the nine regions is presented below.

## BENCHMARK COMPUTATIONS

### Step 1

The first step was to estimate the distribution by herd size for all farms with milk cows in 1969 as reported by the census.

The relevant size categories were 1-19, 20-29, 30-49, 50-99, and 100 or more milk cows. Known were: (1) the distribution by herd size of Economic Class I-V farms (commercial in 1969) only for 1969, (2) the distribution by the same herd size strata of both all farms and Class I-V farms only for 1964 (and 1959), and (3) the number of all farms with milk cows for 1969 and 1964 (and 1959). The differences for 1964 (and 1959) between the number of all farms and Class I-V farms only for each herd size category were the numbers of non-Class I-V farms with milk cows. Their distribution was known for 1964 (and 1959) but had to

be estimated for 1969. The 1969 distribution was estimated, after testing several approaches, by applying the 1964 percentage distribution of non-Class I-V farms to their known total for 1969. The resulting number for each stratum was then added to its known respective number of Class I-V farms and became the size group estimate for 1969 of total farms with milk cows.

<u>Step 2</u>

The second step was to determine the number of milk cows in 1969 on all farms in each size category. Known were the number of cows on Class I-V farms and milk cows on all farms with milk cows. It was assumed, based on census data for 1964 (and 1959), that the average number of milk cows per farm on all farms with 20-29, 30-49, 50-99, and 100 or more milk cows was virtually identical to the average for Class I-V farms only. What remained was to determine the average number of milk cows per farm in 1969 for all farms with 1-19 cows. After some experimenting, it was resolved to treat total milk cows (and mean herd size) on 1-19 cow farms as a residual--the difference between total milk cows on all farms and the sum of the total milk cow estimates for all farms (estimated farm numbers times assumed mean herd size for each stratum).

<u>Step 3</u>

Step 3 was to estimate for each region milk production per cow by herd size. The only uniform set of such data for the United States was contained in the 1964 agricultural census. A special table included (for farms with milk cows on hand year-end 1964) farm milk cow numbers

and pounds of milk and butterfat sold in 1964 by the herd size strata--1-19 (actually an aggregate of $<5$, 5-9, and 10-19 cows), 20-29, 30-49, 50-99, and 100 or more milk cows (actually an aggregate of farms with 100-199 and 200 or more milk cows). (These data also included farms with cows on hand year-end 1964 which did not sell any milk or cream in 1964.) This same table also contained the same information as above, but not by herd size, for all farms that sold milk or cream in 1964 but had no milk cows on hand year-end 1964. Another 1964 census table contained most of the same information as above for all farms that sold any milk or cream in 1964.

The above information was combined in such a way so that total pounds of milk equivalents (pounds whole milk + quarts of milk sold directly to consumers x 2.2 pounds per quart + pounds of butterfat sold ÷ % B.F. for the State) sold in 1964 for each herd size category in each region could be estimated. The respective numbers of farms and milk cows for each size group were known. Therefore, total pounds of milk equivalent (ME) sold per milk cow was calculated. This statistic computed for all farms was checked against the comparable 1964 figure reported by SRS and was reasonably close for most regions.

The proportion of total milk produced represented by sales varies inversely with herd size. Thus, the 1964 census sales per milk cow figures for each region were adjusted upward accordingly by using several sources of published and unpublished data, judgment, and personal experience to tailor these factors to each region.

Milk production per cow for each size category of farms was then indexed to the average calculated for all farms in a region. These index numbers were applied to the milk production per cow statistic computed from SRS published data for each region. Thus, milk production per cow for each size stratum was related to the regional average.

## Step 4

Step 4 involved estimating total milk production per herd size stratum and for the region, the latter to agree with the figure calculated from SRS published data.

A first approximation for each herd size category was made by multiplying average production per cow by the cow numbers reported by the 1964 census. The size strata estimates were then summed, and this sum was checked against the known SRS total milk production figure. In most cases, this comparison was reasonably good. These strata milk production data were indexed to their sum. The index numbers were then applied to the known SRS total. This became the final set of total milk production figures for each herd size stratum.

## Step 5

This step was for the purpose of computing a final set of milk cow numbers for each region. For each category, the adjusted production per cow figure was divided into final total stratum milk production to calculate total milk cow numbers. The individual size strata estimates were summed, and this sum was compared with, and subsequently adjusted to by indexing to the total number, the known (given) SRS total milk cows figure.

Step 6

Step 6 was essentially a "fine tuning" step. The final set of size strata production per milk cow estimates for most regions was calculated by dividing final total milk production by final total milk cows.

Step 7

The final step in this series of computations was to determine for each region the number of farms associated with the milk cow numbers (step 5). This was done for each herd size category by dividing cow numbers by average herd size (included in step 2). The structural variables now defined by region for 1964 a complete and balanced set of structural information for the dairy production sector in the United States. This provided the groundwork that facilitated the complete structuring of the dairy production sector for 1969, a census year for which considerable information was not available compared with the 1964 census.

Step 8

Steps 1 and 2 describe how numbers of all farms with milk cows (a first approximation) and average herd size were determined for each stratum for 1969. The final distribution for 1969 of all farms with milk cows was determined as follows. Total milk cows for a region reported by SRS divided by the average herd size computed for the region using 1969 census data, yielding an estimate of total farms with milk cows. It was assumed that the census average herd size was the true population mean for the region--that is that the census distribution of farms by herd size represented best the true relative proportions of different size farms in the population. In reality, the census counts of larger farms probably was more accurate

than the count of smaller farms. Anyway, the census percentage distribution of all farms with milk cows was applied to the estimated total farms with milk cows corresponding to 1969 SRS total milk cows and the 1969 census mean herd size for all farms with milk cows (calculated by dividing the former by the latter).

Step 9

Milk production per milk cow for all herd size strata in a region was computed from SRS published data for 1969. Production per cow for each stratum was determined by applying the 1964 index of relative production levels by herd size to the 1969 average production per cow for all cows in the region. "Fine tuning" production per cow included advancing the rate of increase in production per cow for the smaller farms relative to the population rate for all herd sizes and retarding the relative rate for larger farms. This assumes, and results in, a narrowing over time of the range in output per cow among various herd sizes.

Step 10

The first approximation of total milk production for each stratum was simply the product of the initial estimate of production per cow and total milk cows. The sum of these estimates (total production for the region) was then compared with the SRS data-based total. The estimate of total production was quite good for most regions.

The percentage distribution by herd size of estimated total milk production was applied to the SRS data-based regional total. The result was the final distribution by herd size strata of total production.

Step 11

This step for most regions and herd size strata was an adjustment of production per milk cow. The adjustment was reached by dividing total production by total milk cows. In some regions, particularly among smaller farms, milk production per cow was judged to be too low relative to levels computed for larger farms. In these cases, "fine tuning" involved adjusting the combination of cow numbers, farm numbers, and total production. It should be noted that adjusting the number of smaller farms or cow numbers on these farms or production per cow is not critical in regard to its impact on total milk production of this stratum. Nor does this stratum contribute importantly to regional production in most regions.

PROJECTING

At this point, a complete and balanced set of dairy production sector structural data have been generated by herd size for 1969 and 1964 for nine regions and the United States by tying 1969 and 1964 census data to annual SRS published data. The key structural variables are: (1) all farms with milk cows, (2) milk cow numbers, (3) average herd size per farm, (4) average production per cow, and (5) total milk production.

Any meaningful projection involves time trend as a basis. In the present situation, projections using only SRS data include only the three structural variables, 2, 4, and 5, whereas a combination of census and SRS data projects the complete structure. A complete projection is particularly useful on a year-to-year basis. Projecting on a 5-year

minimum census period basis is quite risky, particularly when working with all five variables. Several approaches to projecting the complete and balanced set of variables to 1974 and then 1976 were experimented with. The one finally adopted is described below.

Step 1

The 1974 distribution of all farms with milk cows by herd size was estimated for each region using Markov chains. A set of transition probabilities was computed for the 5-year period 1964-69 and then applied to the 1969 distribution of farms. A transition probability matrix was developed for each of two groups of farms with milk cows, all census economic Class I-V (commercial) farms, and noncommercial farms. The two separated projected farm distributions were subsequently summed by herd size strata to arrive at the total of all farms with milk cows.

Step 2

Once the 1974 distribution of farm numbers for various size dairy herds had been determined, comparable distributions for 1970, 1971, and 1972 were estimated by simple linear interpolation between 1969 and 1974. The next step was to create a complete and balanced set of structural information for these 3 years. The basic operating assumptions were: (1) that linear trends (cow numbers per farm and output per cow) were most accurate, (2) that SRS published data for three variables were uniformly the best available, and (3) that the Markov chains transition probabilities for 1964-69 would represent fairly accurately structural changes for at least a couple of years past 1969.

The structure of the dairy production sector was developed first for 1971 because at the time of this research effort late in 1972 and early 1973 the most recent annual SRS data available were for 1971.

The procedure used to complete the set of structural data for 1971 was identical in virtually all aspects to that outlined already in steps 1-11 in the first section of this report. It was discovered that very little "fine tuning" was necessary when adjusting to SRS data for the three variables of total milk cows, total milk production, and output per cow for each region. The same held true for 1970.

Step 3

Based on the complete structural information for 1969, 1970, and 1971, the same was estimated for 1972. The estimating procedures for the various structural variables remained unchanged. The only change was the use for 1972 of a new set of annual transition probabilities generated for each region using 1969, 1970, and 1971 farm numbers.

The resultant set of structural data for 1972 compared very favorably with the three SRS data variables and with independent annual estimates for 1972 of the three SRS data variables based on their monthly data. Also, this study's estimate of 1972 total U.S. milk production compared very favorably with other estimates made within U.S.D.A.

Step 4

A new base period, the 2-year period 1970-72, was used for projecting the structural variables to the target years 1974 and 1976. This base period assumed that the 1972-76 primarily economic conditions would be most like 1970-72 conditions. A matrix of transitional probabilities for each region was generated for 1970-72 and applied to the 1972 and 1974 projected distribution of all farms with milk cows (economic Class I-V and noneconomic Class I-V farms separately). Average milk cows per farm and average production per cow for each herd size

stratum were linear extrapolations of their longer run (1964-69) and shorter run (1969-72) adjusted trends. For each size stratum in each region, projected number of farms times projected mean herd size yielded total milk cows. This calculated total milk cows times projected production per cow yielded total milk production. Total production and total milk cows for the region were the sums of the individual stratum estimates. Production per cow for the region was a weighted average computed simply by dividing the former sum by the latter sum. Average herd size for the region was calculated similarly. All regional estimates were compared with extrapolations of their longer run trends as a quick check on their reasonableness. All regional estimates generated appeared to be reasonable.

The complete and balanced set of structural data generated for all nine regions for 1974 and 1976 discussed in steps 1-4 above represents a continuation of the 1970-72 trends--economic conditions. This set corresponds closest to the 80 percent of parity as of April 1 each year situation posed to ERS as one of three alternative policy actions by ASCS. Two other complete sets of structural data for 1974 and 1976 were generated, one each to reflect the other two policy choices--support at 75 percent of parity as of April 1 annually or a constant support price equal to 85 percent of parity as of April 1, 1973.

The other two sets represented modifications of the initial set. The modifications made were to the matrix probabilities and the trends defined for output per cow and, in some cases, also mean herd size. All adjusting was in accordance with a different set of assumptions related to economic conditions expected under each type of dairy support

policy. Research experience and judgment played an important role in the execution of this task. A meaningful discussion of the economic rationale underlying the specific and numerous adjustments, which varied by region and herd size, would require script of a length at least equal to that already composed. The following paragraph contains a sketch of the basic assumptions underlying, or philosophies of, expected producer response associated with each of the three policy alternatives.

It was assumed that, under the 80 percent of parity policy, U.S. dairy farmers would view the ensuing 5 years, 1972-77, as similar to the past 2 to 3 years and continue to expand production as milk prices rose steadily from an estimated $6.10 in 1972-73 to $7.20 in the 1976-77 marketing year. Under the 75 percent of parity policy, the outlook was less optimistic. Annual increases in milk prices were expected to be smaller and total average U.S. milk production only 0.7 billion pounds, compared with 1.4 billion under the 80 percent of parity policy. The lower milk-feed price ratios were expected to be less conducive to heavy grain feeding and the rise in milk prices slower, which, in absolute and relative to input prices, would slow the rate of herd expansion. The constant support price equal to 85 percent of parity as of April 1, 1973, was expected to result in a mixture of the most favorable short-run and least favorable long-run effects of the other two policy choices. The large immediate increase in milk price to $6.64 in 1973-74 would be expected to induce heavy grain feeding and herd expansion in 1973-74 and probably through 1974-75, followed closely by steadily falling milk-feed price ratios

and narrowing milk price-input cost margins. The latter would be expected to have the greater effect over the longer run by dampening herd size expansion and increasing the exit rate from dairying. Thus, U.S. milk production under the 85 percent of parity policy would increase sharply in 1973-74, increase at a decreasing rate for 2 years, and then decline, beginning in 1976-77.